This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GODFREY LOWELL CABOT
SCIENCE LIBRARY

HARVARD COLLEGE LIBRARY

HARVARD GEOLOGY LIBRARY
CN
6780

University of the State of New York

11.581

New York State Museum

FREDERICK J. H. MERRILL Director

23d REPORT OF THE STATE GEOLOGIST

1903

Reprinted from the 57th Annual Report of the New York State Museum

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1904

M144m-S4-1500

Price 45 cents

University of the State of New York

REGENTS 1908

With years of election

1892 William Croswell Doane D.D. LL.D. *Chancellor*, Albany
1878 Whitelaw Reid M.A. LL.D.
1877 Chauncey M. Depew LL.D.
1877 Charles E. Fitch LL.B. M.
1881 William H. Watson M.A. M.
1881 Henry E. Turner LL.D.
1883 St Clair McKelway M.A. L
1885 Daniel Beach Ph.D. LL.D.
1890 Pliny T. Sexton LL.D. –
1890 T. Guilford Smith M.A. C.
1893 Lewis A. Stimson B.A. LL.
1895 Albert Vander Veer M.A.
1895 Charles R. Skinner M.A. LL.D.
Superintendent of Public Instruction, ex officio
1897 Chester S. Lord M.A. LL.D. – – – Brooklyn
1900 Thomas A. Hendrick M.A. LL.D. – – – Rochester
1901 Benjamin B. Odell jr LL.D. Governor, ex officio
1901 Robert C. Pruyn M.A. – – – – – Albany
1902 William Nottingham M.A. Ph.D. LL.D. – Syracuse
1903 Frank W. Higgins Lieutenant Governor, ex officio
1903 John F. O'Brien Secretary of State, ex officio
1903 Charles A. Gardiner LL.B. M.A. Ph.D. LL.D. New York
1903 Charles S. Francis B.S. – – – – – Troy
One vacancy

SECRETARY

Elected by Regents

1900 James Russell Parsons jr M.A. LL.D.

DIRECTORS OF DEPARTMENTS

1888 Melvil Dewey M.A. LL.D. *State Library and Home Education*
1890 James Russell Parsons jr M.A. LL.D.
Administrative, College and High School Dep'ts
1890 Frederick J. H. Merrill Ph.D. *State Museum*

University of the State of New York

e Museum

LL Director

Compliments of

John M. Clarke

Director, Science Division

STATE HALL, ALBANY N.Y.

TATE GEOLOGIST

1903

Reprinted from the 57th Annual Report of the New York State Museum

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1904

CONTENTS

Geology 6

  Maps 6

  Precambrian and crystalline rocks.................. 6

  Pleistocene 8

  Economic geology 12

  Mineralogy 13

Peat: its Formation, Uses and Occurrence in New York. Arthur L. Parsons.................................... 15

Notes on the Gypsum Industry of New York. Arthur L. Parsons 89

Abrasives of New York State. Harry C. Magnus.......... 158

Minerals not Commercially Important. Herbert P. Whitlock 180

Distribution of Hudson Schist and Harrison Diorite in the Westchester County Area of the Oyster Bay Quadrangle. F. J. H. Merrill, assisted by H. C. Magnus.............. 193

The Northeast Extremity of the Precambrian Highlands. F. J. H. Merrill, with map by T. Nelson Dale........... 195

University of the State of New York

New York State Museum

23D REPORT OF THE STATE GEOLOGIST 1903

To the Regents of the University of the State of New York

I submit herewith my report as State Geologist for the fiscal year ending Sep. 30, 1903. As usual, this report is mainly administrative, and the more important papers based on the results of the year's work are issued as bulletins to permit of earlier and wider distribution.

Respectfully yours

FREDERICK J. H. MERRILL

GEOLOGY

The work of this division has continued along the lines of investigation previously in progress. As usual, the autumn, winter and spring have been occupied with the preparation of maps and other matter for publication, and the summer season has been devoted to field work.

Maps

The demand for an up to date geologic map of New York, of moderate size, has led to the preparation for the publication of a new edition on the scale of 15 miles to the inch, which shall extend a short distance beyond the New York State boundary in all directions, so as to show the geologic relations in the immediately adjoining territory. Tracings of the 5 mile base map for reduction to the scale of 15 miles to the inch were prepared under the supervision of Mr C. C. Vermeule, while tracings of the territory adjacent to New York have been prepared in the office by Mr H. H. Hindshaw. The manuscript was placed in the hands of the contractors for engraving, Messrs A. Hoen & Co., in September, and the map will probably be issued within 12 months.

The hypsometric map issued with the 21st Report of the State Geologist has met with a reception indicating much appreciation of its value, and, in accordance with the request of Professor Landreth, is to form a plate in the next report of the State Water Storage Commission, by permission of the University.

Accompanying this report is a map of New York State which shows, by various conventions, the distribution of its mineral resources.

Pre-Cambrian and crystalline rocks

In August the State Geologist took up a comparative study of the rocks of eastern Berkshire county, Mass., as an important help in working out the classification of the crystalline rocks of the Highlands of Putnam county, and the adjacent territory in New York, on which he has been engaged at intervals since 1884. In this he was aided by Mr H. C. Magnus, who had formerly taken part in the work on the Highland area between West Point and Peekskill, and who was occupied during the spring with the mapping of that portion of Westchester co. included in the Oyster Bay quadrangle.

Two weeks were spent in the Berkshire region and two weeks more in the study of the pre-Cambrian and other crystalline rocks on the shores of Long Island sound between New London on the east and Fairfield on the west.

Then, returning to Pittsfield, some further time was spent in reconnaissance trips from Williamstown on the north to South Norwalk on the south and eastward as far as Springfield. In the course of this work much benefit was derived from conferences with Professors Dale at Pittsfield, Cleland at Williamstown and Gregory at New Haven.

This work has been necessitated by the great mass of geologic investigation carried on in western New England during the past 15 years, on formations in part identical with those of southeastern New York.

In the Adirondack region, Prof. H. P. Cushing had prepared to continue his work of previous seasons, but during the past summer the heavy rainfall rendered field work in the woods impossible except on comparatively few days. It had been intended to finish the mapping of the Long Lake sheet; but, for the above reason, only about half of the work was completed. In the area covered, attention was mainly centered on the hard geology, and the experience of previous seasons was corroborated in that the anorthosite was found, in this district, to grade invariably into a gneissoid gabbro along its border and to become involved with, and apparently cut by, a gneissoid and rather basic phase of the adjoining syenite. Later, a short visit was made to the Little Falls region to clear up one or two points connected with its geology.

In the office the areal mapping of the Little Falls sheet has been transferred by Professor Cushing to the revised map of that quadrangle, which has recently appeared, and the maps transmitted for publication. A short report on the petrography of the Northumberland rock was transmitted by him for publication in the 21st Annual Report of the State Geologist. Much time during the year was devoted to the preparation of a report on the geology of the northern Adirondack region; and it is well advanced toward completion, so that it will be forwarded for publication early next spring.

Pleistocene

During the field season of 1903 Professor J. B. Woodworth continued his work on the Pleistocene geology of the eastern part of the State. Work was begun in the month of April on the remapping of the Harlem and Brooklyn quadrangles, Mr J. W. Goldthwait being charged particularly with the detailed mapping of the outcrops of bed rock not heretofore shown on geologic maps. This work was advanced by Mr Goldthwait during the summer season to the point of showing in detail the surface geology of the major part of the southern half of the Harlem quadrangle and that of the Brooklyn sheet except the area within the city of Brooklyn. The plan of showing the position of the hundreds of small rock exposures in the former area as an index to the distribution of the thin till, rendered the field work necessarily slow. Mr Goldthwait, on account of illness, was forced to leave the field in the middle of August and has not since returned to it. The glacial striation in the mapped portion of the Harlem area was studied in detail and, through the occurrence of newly made sections, some advance was made in differentiating into definite categories, deposits of drift which heretofore have been represented as undifferentiated glacial materials. Another season's field work will be required to complete the area undertaken.

Several days were devoted by Professor Woodworth during the spring and summer to following the progress of the borings made in the western part of Long Island by the Commission for Additional Water Supply. The sections thus obtained threw much additional light on the structure of the outwash plain, particularly in the area of the Hempstead sheet. A detailed investigation was carried on at the same time in the area by the United States Geological Survey, a preliminary report of the observations of which, including data from many deep wells privately undertaken, has appeared in various journals. Of the large number of samples of gravels, sands and clays obtained by the Commission referred to, small samples were allotted to the State Museum and are now in Mr Woodworth's charge for such use as can be made of them.

From the 6th of July to the 13th of August Professor Woodworth was granted leave of absence in order to attend to his duties as instructor in one of the summer schools of Harvard University. On the 17th of August he proceeded to Norwood N. Y., where he was joined by Professor Coleman of Toronto Can., and, accompanied by that geologist, conducted a rapid review of the shore lines and evidences of marine submergence lying between Mooers Junction and Adams Center on the southern side of the St Lawrence valley. The primary object of this expedition was to obtain the expert advice of a geologist whose familiarity with the similar phenomena on the Canadian side of the St Lawrence and Ontario valleys was deemed of the highest value in settling mooted points regarding obscure indications of shore lines in this district.

In the course of this examination, Professor Coleman found marine shells (*Macoma groenlandica*) in clays on the outskirts of Ogdensburg. Later, Messrs Coleman and Woodworth found abundant traces of marine shells in stratified sands near the boundary line between the towns of Lisbon and Ogdensburg, including *Macoma calcarea* and one specimen of *Cylichna alba,* a very rare shell within the limits of the State, the only other known locality being that at Port Kent, where it was early noticed by Professor Ebenezer Emmons, and where but two specimens have been collected in the course of this investigation. These Ogdensburg localities are at an elevation of about 275 feet above the sea.

At Norwood, sewer openings which were made in the summer of 1903 revealed many new localities of marine shells, invariably *Macoma groenlandica.* On the hill north of the village, those shells were found in the clays from the sewer trench at an elevation of 360 feet above the sea by the aneroid barometer, or an elevation of 370 feet according to the engineer's levels tied to the railroad elevation at the station. This locality is the highest yet reported within the limits of the State. The highest known shell locality on the eastern side of the Adirondacks in the Champlain valley is at about 346 feet on the Saranac river at Freydenburg's mills. A locality on the Big Chazy river near Mooers is at about the same level. These marine shells occur through the clayey ground in the village of Norwood (Potsdam Junction of the old maps of the State). This elevation of 360 feet agrees very closely according to Professor Coleman with the upper limit of marine shells on the north side of the St Lawrence valley near Brockville in Canada. Professor Woodworth also reports an occurrence of marine shells in gravel pits along the road between Mooers Junction and Hemingford, Quebec, near the latter place at an elevation of about 270 feet (aneroid). The shells are mostly *Saxicava rugosa* in an excellent state of preservation.

The locality on the Big Chazy near Mooers was found this season and has furnished *Saxicava rugosa, Macoma calcarea, M. groenlandica, Leda arctica, Yoldia* cf. *sapotilla,* and *Balanus* sp.

Marine shells were also observed in a trench in gravels about 1 mile west of Perry's Mills at an elevation of about 300 feet.

Mr William D. Stevenson, customs officer at Mooers Junction, states that he saw shells at a depth of about 8 feet in a well excavated some 15 years ago at McDowell's store near the railroad station at Mooers Junction. There is a marked sand and gravel delta here at an elevation of 280 feet.

A few marine shells (*Macoma groenlandica*) were also seen this last season in a small sand hillock at an elevation of 300 feet on the north side of Tracy brook in the town of Chazy, where that stream is crossed by the state road from West Chazy to Sciota.

The latter part of August and the first part of September were devoted by Professor Woodworth to the completion of the mapping and study of the Mooers quadrangle, the work on which had been far advanced during the preceding season. Search was directed particularly to the finding of marine shells in stream banks and to the tracing of the shore lines which traverse this area. This map has been prepared to show the distribution of beaches, whether marine or lacustrine. The attempt made last season to discriminate the different classes of drift of glacial origin in the low submerged tract below the 600 foot line was perforce abandoned for most of the area, when it became evident that the glacial deposits had been worked over by the action of waves and currents during the epoch of submergence so as to confuse and commingle materials of diverse origin.

For the purpose of obtaining information concerning the tilted attitude of the beaches and the marine limit in this district, two visits were made to outside points in Canada, the first to the vicinity of Ottawa, and the other to the isolated igneous masses near St John's and Beloeil, in Quebec.

In the case of Monnoir or Mt St John near St Grégoire, no definite upper limit of wave action was observed. The northern and eastern slopes were largely bared of drift. What appear to be fractures partly filled with blocks riven from their walls, are striking features in the upper part of this mount on its eastern aspect. The fractures extend in a northwesterly and southeasterly direction. Professor Woodworth could not determine at the time of his visit that the narrow openings were due to excavation of nonresistant material by waves.

A visit to Beloeil showed heavy pebble beaches developed about the base of this mountain on the west up to an elevation of from 310 to 320 feet above sea level by aneroid compared with the hight of the rail at St Hilaire. An ascent of the northwestern part of the mountain showed no traces of beaches or wave action, but the slopes were everywhere too steep to record clear indications of marine action.

From Ottawa, a reconnaissance was made of the slopes of Kingsmere mountain, northwest of that city, between Chelsea on the Gatineau, and Kingsmere postoffice. Traces of shore lines were found between Old Chelsea and Kingsmere postoffice at 480, 550, 640 and 705 feet by aneroid set at Chelsea Station. A heavy deposit occurs along this road at about 800 feet; but Professor Woodworth was not able to find the criteria which would satisfy one that it marked a shore line; much less that it was of marine origin. The ascent was continued at the Kingsmere post office up to 965 feet to the northward, but no definite shore lines were seen.

Professor Woodworth is indebted to the Geological Survey of Canada for advice and literature concerning the study of shore lines about Ottawa, and particularly to Dr R. W. Ells for personally conducting him to the Pleistocene phenomena of the Hull district. He also wishes to express his obligation to Joseph Hobson, chief engineer of the Grand Trunk Railway, at Montreal, for information concerning the altitudes of stations on that road.

During the latter part of the season, Mr P. T. Coolidge, of Watertown Mass., accompanied Professor Woodworth as a voluntary assistant in the search for shore lines and marine shells. Mr Coolidge reports the finding of *Mytilus edulis* in the delta deposits at Port Kent south of the railroad station.

Incidentally, Professor Woodworth reports, as having fallen under his notice in the course of the above journeys, the occurrence of trails of Protichnites on a ripple-marked sandstone layer of the Potsdam at high-water mark under the bank of Lake Champlain at Port Kent near Trembleau Hall.

Professor Woodworth has also prepared a report of progress on the Champlain district, being essentially an account of the general surface geology of the Mooers quadrangle, comprising portions of the towns of Mooers, Altona, Chazy, Beekmantown and Dannemora. A detailed statement of the results of the study of water levels on this area is to be embodied in a report on the marine submergence following the glacial period.

This report forms a Museum bulletin.

Owing to the absence of Prof. H. L. Fairchild in Europe, no investigations were conducted in the work under his charge.

Economic geology

In economic geology, papers on peat and gypsum were completed by Mr A. L. Parsons and an article on abrasives in New York was prepared by Mr H. C. Magnus.

A rearrangement of the collections in economic geology was made in the early part of the year in order better to display them under the improved conditions of lighting in the first floor of the rear wing, to which three new windows have been added.

Mr H. H. Hindshaw, assistant in geology, has been occupied with the compilation of statistics of the mineral products of the State, in editing and reading proof on bulletin no. 62, entitled *Natural History Museums of the United States and Canada,* and in completing for the engraver the hypsometric map of New York.

During the past year the Director has been in correspondence with the New York State Louisiana Purchase Exposition Commission in regard to an exhibit of the mineral resources of New York and has attended one of its meetings. It is probable that an extensive exhibit from the State Museum will be installed at St Louis.

Mineralogy

In the division of mineralogy the principal work of publication consists of a list of the mineral localities of New York State arranged by counties, which has just been completed and will be shortly issued as bulletin 70, mineralogy 3. In this work Mr Whitlock has systematically arranged in tabular form the data collected from various published authorities and embodied such notes and additions furnished by field reconnaissance and study of specimens in available collections as are necessary to make the bulletin a useful work of reference on New York mineralogy, to teachers, students, collectors and curators.

A bibliography, consisting of 231 references to published articles on New York mineralogy, is embodied in the text.

The educational work of the division of mineralogy has been advanced by giving two public lectures, in Graduates Hall of St Agnes School, on subjects connected with mineralogy. The lectures were illustrated by 57 lantern slides and 23 slides showing artificial crystallizations, which were prepared by the division of mineralogy and are available for future work along this line.

The curatorial work of this division has progressed along several lines. The plan of placing group and explanatory labels throughout the exhibited material has been developed to a considerable extent. The large collection of duplicate mineral material formerly stored in various places throughout the building has been assembled, sorted and classified, so that duplicate specimens are now readily available.

Additions to the mineral collections have been made by several field excursions, among which may be mentioned in particular a collecting trip to the mines of the Newark Cement Co. at Rondout, which resulted in the acquisition of a large and complete series of calcite and associated minerals from that locality.

PEAT

ITS FORMATION, USES AND OCCURRENCE IN NEW YORK

BY

ARTHUR L. PARSONS

NOTE BY THE STATE GEOLOGIST

In my 21st annual report I published a paper by Dr Heinrich Ries on "The Uses of Peat and Its Occurrence in New York," which represented the available information at that time. In continuation of the work done by Dr Ries, Mr Arthur L. Parsons has prepared the following paper, which, while duplicating a part of what Dr Ries has published, forms a *résumé* of our present knowledge on the subject of this material, which probably in the near future will become of economic importance through the development of processes for cheaply making it into available fuel.

F. J. H. MERRILL

CONTENTS

PAGE

Part 1

Introduction 18
Inundated lands 20
Classification of swamps.............................. 21
Description of swamps.............................. 21
  Marine marshes 21
  Mangrove marshes 23
  Fresh-water swamps 23
  Lake swamps 23
  River swamps 25
  Delta swamps 25
  Upland swamps 26
  Climbing bogs 26
  Ablation swamps 26

Part 2

Classification of peat based on vegetation.......... 27
Classification of peat based on physical condition... 27
Process of peat formation.............................. 28
Analyses of peat.............................. 32
Methods of determining fuel value.............................. 36

Part 3

Economic value of swamps.............................. 38
  Timber 38
  Marsh grass and cat-tails.............................. 38
  Moss litter 38
Peat fuel 39
  Methods of preparing peat for fuel.............................. 42
  Mechanical treatment of peat.............................. 44
Peat coke and volatile products.............................. 59
Agricultural value of peat.............................. 61
Associated products 62
  Marl 62
  Clay 63

PAGE
Infusorial earth 63
Bog iron ore................................. 63

Part 4

Distribution of swamps in New York State........ 63
Salt marshes of New York State................ 64

Part 5

Description of important swamps in New York State. 68
Drowned lands of the Wallkill................. 68
Greycourt meadows 72
Stissing pond 72
Deuel swamp 73
Cicero swamp 74
Pleasant lake 77
Phoenix 78
Owl's Head 78
Madrid and Knapp's......................... 79
Montezuma marshes 80
Pinnacle marsh, Rochester.................... 83
Oak Orchard swamp.......................... 83
Byron 84
Caledonia 85

Part 6

Bibliography 85

PEAT

ITS FORMATION, USES AND OCCURRENCE IN NEW YORK

PART I

INTRODUCTION

The purpose of this paper is to give reliable information concerning the occurrence, formation and uses of peat, and descriptions of the principal deposits of this material in this State. Geologic considerations have not been taken up in detail, because it is chiefly the aim of the author to discuss the economic importance of the material in agriculture and the arts. Many attempts have been made by different people at various times to prepare and market peat in New York State, but heretofore the undertakings have soon been given up. During the summer of 1902, when it was almost impossible to secure anthracite coal in New York city, peat was brought to the city from some of the swamps on Long Island; but, in spite of the demand for fuel, there was little or no sale for this material. A careful inspection of the more important deposits in the State and a study of the fuel value of peat of average composition and the products which may be obtained from it have forced on the author the conclusion that peat deposits may be utilized to advantage as sources of fuel when the material is properly prepared. In most European countries peat is used quite extensively, and new processes of manipulating the raw material give a product that is finding favor in all kinds of manufacturing establishments.

Peat is thus defined by the *Standard Dictionary:* "A substance consisting of partially carbonized vegetable material, the result of the decomposition of various plants (sometimes aquatic) in the presence of water; found usually in marshes, bogs, etc. At the surface it contains considerable water, but deeper it is more compressed and gradually approaches the condition of lignite."

It is in fact the first stage in the process of coal formation. The definition given above gives only a vague idea of the character of the substance, and, in order to understand its nature, it is necessary to make a study of the conditions governing its formation, and to this end a classification and description of swamps and marshes must be given.

The value of the swamps in New York State is ordinarily greatly underestimated both from lack of information in regard to their extent and ignorance of the manner in which they may be reclaimed for agricultural purposes. Ordinarily unimproved swamp land is assessed at about $5 per acre, but, when this same land is drained, it sells ordinarily at from $200 to $500 per acre, so that, when it is known that the estimated area of the swamps of New York is more than $\frac{1}{20}$ of the State,[1] the enormous value of these tracts is at once apparent.

It is impossible to give a complete list of the swamps of the State, because in many cases the deposits may cover only a few acres or even less than an acre, but a study of the topographic maps of the United States Geological Survey will give the location of the more important ones, though it must ever be borne in mind that all swamps are not peat deposits, though all peat deposits are or have been swamps. Many of these swamps are spoken of as muck swamps even when the best of peat is found in them, and the term peat is not common in referring to swamp deposits in this country. The reason for this is undoubtedly the fact that peat is used in this country almost entirely as a fertilizer. The original meaning of the word muck is moist manure. From its resemblance to stable manure, peat came to have the same name, more particularly because the two were commonly mixed to make a compost. The name thus came to be applied to peat when used as a manure. Again, peat containing a large percentage of ash is known as muck, possibly from the fact that this kind of peat would be used as a manure, while the better peat was saved for fuel.

---

[1] Shaler estimates the area of inundated lands in New York State to be between 2000 and 3000 square miles. U. S. Geol. Sur. 10th An. Rep't, p.311.

In general, a swamp or marsh is formed when the drainage in any locality is so arrested that sufficient water is retained to prevent complete decay of the vegetable matter that may be deposited. The greater amount of vegetable matter that accumulates in a swamp is not due to the increased luxuriance of the vegetation; in fact, the amount of vegetable matter that may be deposited on the uplands may be greater than that which accumulates in a swamp. On the upland, where the drainage is unimpeded, any accumulation of vegetable matter is exposed to frequent alternations of moisture and drouth, which hasten the process of decay; but in a swamp, where the moisture is always about the same, the decomposition is very slow, and is rather a process of deoxidation than oxidation, or decay. The various processes of decomposition are well shown in a fence post when set in moderately moist soil. The portion above ground is to all intents and purposes in a dry atmosphere, and the rate of decay is very slow. For a few inches above and below the surface of the ground the decay is very rapid, because the soil retains the moisture after rains; but in time of drouth this part becomes dry. This alternation of moisture and drouth furnishes an ideal condition for decay, and, when a post breaks, it is invariably at this point. Below this zone of decay the moisture is more constant, and the decay is less, and in many cases, when an old post is dug up, it is found to be sound at both ends and almost rotted off at the surface of the ground. This will serve as an explanation of the fact that all that may be left of a great deposit of vegetable matter where drainage is unimpeded is a thin deposit of mold, while the same amount of vegetable matter in a swamp forms a thick bed of peat, which in some cases may be fifty or even a hundred feet thick.

Inundated lands

The most complete classification of inundated lands that has come to the notice of the author is the one by Shaler [10th An. Rep't U. S. Geol. Sur. p. 264] which is given below.

Classification of swamps

Marine marshes	Above mean tide	Grass marshes
		Mangrove marshes
	Below mean tide	Mud banks
		Eel grass areas
Fresh-water swamps	River swamps	Terrace
		Estuarine
	Lake swamps	Lake margins
		Quaking bogs
	Upland swamps	Wet woods
		Climbing bogs
	Ablation swamps	

Description of swamps

The distinction made by Shaler between the terms marsh and swamp, confining the former to marine formations and the latter to fresh-water deposits, is one which might be carried still farther to distinguish between bog, mire, morass etc. It seems to be the general impression that all these wet lands are areas of soft, black mud and slime overgrown to a certain extent with marsh grasses and cat-tails, which form a mire that is absolutely impassable, whereas most fresh-water swamps have a floor of moss or interlaced roots and fallen trees which make a perfectly safe foothold for the person who may attempt to cross.

In New York State examples of all the above mentioned classes of swamps are to be found with the exception of the mangrove marshes. As a rule, only the fresh-water swamps of the State are of any importance as sources of peat, though the value of the salt marshes, if reclaimed, would be very great as farm or garden lands.

Marine marshes. The four classes of marine marshes, though entirely distinct, are not as widely separated as appears at first; they are in fact separate steps in the same process. For a strictly logical classification the arrangement would be, (1) eel grass areas, (2) mud banks, (3a) grass marshes and (3b) mangrove marshes.

These marine marshes are in most cases formed in bays where the wave action is slight. Their history in general is as follows: The waves wear away large quantities of material from rocky headlands and beds of glacial drift. The rock fragments are carried to adjoining beaches, where the pebbles are slowly ground to a fine mud, which may be carried by even a slight current to a great distance. Clay from the drift is reduced to the same condition. The mud is not deposited to any great extent where the waters are disturbed; but, when it is driven into protected bays, it slowly settles and forms a bed on which a crop of eel grass rapidly springs up. These eel grass fields are usually covered with 3 or 4 feet of water at half tide, when the tidal current is greatest. On account of the habit of the plant, the tidal current is practically stopped where the grass is growing, though the water above the grass is usually more or less laden with fine mud, which slowly settles to the quiet water below and, becoming entangled by the stems of the grass, gradually increases the thickness of the deposit in this place. The dying portions of the eel grass and the bodies of many Crustacea and Mollusca are deposited with this mud and rapidly increase the thickness of the deposit. When the deposit reaches such a thickness that it is dry at low tide, the eel grass ceases to grow, and the increase in the deposit comes entirely from the sediment borne in by the tide. On the highest part of the mud flat thus formed, grasses and other forms of vegetation begin to grow and gradually form a covering which raises the level of the marsh so that it is only overflowed by the highest tides. Sometimes the mud flat between the eel grass area and the grass marsh is as much as a mile wide, but this is exceptional. The growth of the deposit is more rapid in the grass marsh than in the eel grass area, because the plant, leaves and stems are larger, and for this reason gather sediment more effectively. The grassy marshes are more carbonaceous than the eel grass areas, but they rarely contain 50% of carbon and usually do not furnish a supply of peat suitable for fuel.

When reclaimed by drainage, they make excellent garden land, though the cost of drainage is greater than in the case of most fresh-water swamps.

Mangrove marshes. South of Fernandina and thence throughout Florida, mangrove marshes take the place of grass marshes. The roots of the mangrove develop in salt water, and the plant spreads by means of rootlike processes which implant themselves in the marine mud, while the tree itself is entirely above water.

Fresh-water swamps. Though marine marshes and fresh-water swamps are sharply defined in the character of the vegetation and in the periodicity of inundation, the two have their point of meeting in the estuarine or delta swamps. It is hard to draw the line of distinction between the different classes of fresh-water swamps and a study of conditions will force on the student the conclusion that all fresh-water swamps are modifications of lake swamps. The causes of lake formation in general will not be discussed for the reason that this article has only to do with lake filling. A logical treatment of the subject might start with a discussion of any one of the four classes of fresh-water swamps, but for convenience the author will discuss them. in the order given below:

1 Lake swamps
    1a Lake margins
    1b Quaking bogs
2 River swamps
    2a Terrace
    2b Estuarine or delta
3 Upland swamps
    3a Climbing bogs
    3b Wet woods
4 Ablation swamps

Lake swamps. Near the shores of almost any lake or pond a growth of rushes and other aquatic plants may be seen, and usually they are found more abundant in sheltered bays where the waves have very little effect. This growth of plants retards the motion of the water, so that any sediment which may be in the water is deposited, and at the same time the shore is not subjected to the beating of waves. Under these conditions a fringe of moss springs up and rapidly spreads out over the surface of the water. Just a little in advance of the mosses a floating mat of cat-tails is usually found, which is an important help in the spread of the moss by furnishing greater protection from the waves than is given by the rushes alone. Though these mosses grow most luxuriantly in such locations, the growing part must be slightly above the water level, and the cat-tails furnish a support on which the mosses grow more rapidly than when alone, because more of the growing part is above the water.

As soon as the moss has formed a mat over the surface, certain grasses and ferns spring up and add to the deposit of organic material formed by the dead plants. As the mat becomes deeper, heath plants begin to grow and by their more woody stems help to make a more porous deposit, on which larger bushes take root. As soon as the mat becomes deep enough to reach the bottom of the lake near the shore, the deposit gradually rises above the level of the waters of the lake, and small trees find suitable conditions for their growth. The effect produced by the trees and bushes is to form clumps of vegetation above the general level of the moss, so that many trees which ordinarily are not supposed to endure such moist conditions grow in luxuriance.

Such a bog in time will entirely cover the lake, and the zone of rushes and water lilies will be the first to be eliminated, then the cat-tails disappear, and the moss and other plants will occupy the entire surface. In the center of the lake a quaking bog will be left; but, by the gradual filling both by pressure from the growth of the lateral deposits and by the deposition of decomposed particles from the overlying vegetation, the bog becomes a solid mass of peat. As soon as this occurs, the level of the entire bog begins to rise, and the spread of bushes and trees over the entire surface is very rapid.

In some cases the floating bog becomes heavier than the water and "either breaks and sinks suddenly to the bottom or is slowly and gradually lowered into it and covered with water."[1] Authentic instances of such sinking are rare; but about the year 1500 a forest in the Valdes-Ponts sank in one night, giving place to the Lac d'Etaillères. In this way most, if not all, of the submerged forests have probably been formed and brought to their present position, and it is the most logical explanation that can be given for the alternation of peat and marl in many swamps.

River swamps. Terrace swamps are in certain respects merely modifications of lake swamps and are formed in depressions in river valleys. These depressions are caused in a great measure by the deposition of sediment near the river bank in time of high water, thus forming a dike which prevents any water which may overflow from the river from again returning to the watercourse when the flood recedes. The pools formed in this way become more or less covered with swamp vegetation and in time are filled with a deposit of impure peat and muck. The oxbows or moats of a river system, when cut off from the river, form pools which fill up in the same manner as a lake, though floods leave deposits of mud on the surface of the vegetation, thus forming a more mixed deposit than is formed in a true lake, where little sediment can reach the still water beneath the floating vegetation, and none at all can go above it.

Delta or estuarine swamps. The dikes or levees formed by a river naturally extend to its mouth and are gradually extended beyond the shore line. In many cases the river breaks through this wall and may have several outlets, thus forming a delta. The space between these outlets is usually lower than the banks of the river, and swamp vegetation springs up and a delta swamp is the result. In case this delta is at the head of a lake, the gradation from the delta formation to the lake margin swamp may be so gradual as to make it difficult to tell where the line of division should come. True delta swamps are not common in

---

[1] Lesquereaux, L. Pa. Geol. Sur. An. Rep't. 1885. p.107–8.

New York, though the "vleys," or swampy borders of the Hudson come under that head.

Upland swamps. Upland swamps are found in regions which are approximately level. In a region where the surface does not have a fall of more than 4 or 5 feet to the mile, any vegetation which may spring up has a tendency to retard the flow of the rain-water. When leaves or the trunks of trees fall, they act as a sponge and retain the water, thus furnishing better conditions for the growth of mosses and grasses. If the plain is originally a woodland, the forest may be destroyed by the swampy conditions thus produced, or it may be replaced by a growth of the trees that are ordinarily found in swamps. It may seem far-fetched to call such a swamp a modification of a lake swamp; but, when one considers that every fallen twig and every root is a dam which holds back the water, it is apparent that the whole area is made up of little lakes which furnish the proper conditions for the growth of the swamp vegetation. In such a swamp the rush and cat-tails stage may be entirely lacking, and the sphagnum and grasses will be the most important factors in the swamp formation.

Climbing bogs. Climbing bogs are the natural spread of any swamp to higher levels on account of the great amount of moisture that is absorbed by the sphagnum and other mosses of the swamp, but they are of no importance in this State.

Ablation swamps. Ablation swamps, otherwise known as corrosion spring swamps, are not common, but are caused by the gradual subsidence of the surface of the ground on account of the solvent action of water on either the surface rock or some of the underlying strata, forming a pool or depression in which swamp vegetation springs up. The solution of salt and gypsum in central and western New York is without doubt an important factor in the formation of swamps in that part of the State, though in most cases other causes have an important share.

Upland swamps and ablation swamps do not depend to such a degree on the presence of terrestrial water for their growth as the lake and river swamps, but get a large part of the moisture necessary for their formation from a humid atmosphere. In some cases springs may furnish the supply of water; and in the case of some swamps in glacial kettles the only apparent supply is rain water.

PART 2

Classification of peat based on vegetation

Somewhat dependent on the differences in inundated lands is the classification of peat based on the variety of plants which go to make up the mass. Though no large mass of peat is made up of any one kind of vegetation; yet a general distinction can be drawn which is based on the most important class of plants present. The following classification is given by Wagner:[1] (1) "bog peat consisting principally of species of sphagnum; (2) heath peat, formed chiefly from the roots and stems of Erica and Calluna; (3) meadow peat, formed principally from grass and sedges; (4) forest or wood peat, formed from the wood of trees; (5) sea peat, formed from sea weeds."

Some difficulty is encountered in referring some of the New York deposits to any one of these classes, because of the many important varieties of vegetation present in the same swamp. There is no difficulty in referring the Montezuma marshes to the third class, inasmuch as they are principally composed of cat-tails and grasses; but in the case of the Cicero and Oak Orchard swamps and the Drowned Lands of the Wallkill, it is decidedly a question; borings bring up pieces of wood from all depths, and the surface is covered with a luxuriant growth of trees, but at the same time sphagnum and other mosses form a dense carpet, which rapidly covers any fallen trees and may furnish a greater amount of material than the trees. Shrubs and heath plants are also found, so that these swamps seem to be filled with a more composite deposit than is indicated by any of the classes given by Wagner.

Classification of peat based on physical condition

Another classification that has been used is based on the difference in texture of the upper and lower layers of the deposit.

---

[1] Wagner, Rudolph. Manual of Chemical Technology.

Cleaveland in his mineralogy[1] distinguishes between (1) fibrous peat, or turf, and (2) compact peat, or peat proper. His definition and description of peat are so good that I quote them in full.

> Peat consists essentially of vegetable matter in various states of decomposition; but is more or less mixed with earths and salts. It appears to differ from vegetable earth [or mold] by retaining nearly all the principles of the vegetable, though these principles may have formed combinations which did not exist in the living plant.
>
> We notice two varieties of peat, depending chiefly on the degree of decomposition in the vegetable. (1) Fibrous peat. This variety, sometimes called turf, is composed chiefly of vegetable fibers, variously interlaced, and united by a slimy, vegetable matter in a more advanced state of decomposition. Its texture is of course very loose. Hence we perceive the roots, stems and leaves of various plants, which grow in swamps, bogs, marshes or heaths; indeed, it sometimes seems to be composed almost entirely of leaves. When dry, it is lighter and more elastic than compact peat, and its color is usually less dark. (2) Compact peat. When recently dug, it forms a very slimy mass, soft to the touch, and sufficiently tenacious to be cut or molded into small regular solids, like a brick. When dry, its texture becomes more or less firm and compact, and it exhibits an earthy fracture. It is harder, heavier and blacker than the first variety. It embraces few or no visible remains of the organic parts of vegetables and seems to have originated chiefly from aquatic plants. In some rare instances its fracture is glossy like resin.
>
> The two preceding varieties pass insensibly into each other and frequently occur in the same bed. In this case, the upper part of the bed is loose and fibrous, having undergone only partial decomposition; but, on approaching the lower parts, the remains of the vegetable fiber gradually disappear, and the peat becomes more compact, in consequence of the more complete decomposition of the vegetable and of the pressure of the superincumbent mass.

Process of peat formation

The manner in which a peat bog is formed has been described under the head of lake swamps, but the process of peat formation is a subject for theories. It is known that the vegetable matter loses certain percentages of carbon, hydrogen and oxygen, but just what the chemical changes are which take place is unknown. The process of peat formation is the first stage in the formation of coal, and the following table[1] shows the manner in which peat and the principal varieties of coal may be formed from woody tissue by the loss of constituents.

---

[1] Cleaveland, P. Elementary Treatise of Mineralogy and Geology. 1822.

		C	H	O	total	
	Wood	49.1	6.3	44.6	100	
	Loss	21.5	3.5	29.1	54.1	Loss equivalent to 40% CO_2 and 14.2% CH_4
I	Peat	27.6	2.8	15.5	45.9	
	Percentage	60.1	6.1	33.8	100	
	Loss	8.1	2.2	21.5	31.8	Loss equivalent to 29.6% CO_2 and 2.2% H, uniting with outside O
II	Peat	41	4.1	23.1	68.2	
	Percentage	60.1	6	33.9	100	
	Loss	2	1.6	18.15	21.75	Loss equivalent to 7.33% CO_2 and 14.42% H_2O
III	Peat	47.1	4.7	26.45	78.25	
	Percentage	60.2	6	33.8	100	
	Loss	18.65	3.25	25.4	= 47.3	Loss equivalent to 34.9% CO_2 and 14% CH_4
IV	Lignite	30.45	3.05	19.2	= 52.7	
	Percentage	57.8	5.8	36.4	100	
	Loss	6.4	1.95	17.2	25.55	Loss equivalent to 23.6% CO_2 and 1.95% CH_4
V	Lignite	42.7	4.35	27.4	74.45	
	Percentage	57.3	5.8	36.9		
	Loss	1	1.4	13.75	16.15	Loss equivalent to 3.6% CO_2 and 12.5% H_2O
VI	Lignite	48.1	4.9	30.85	83.85	
	Percentage	57.3	5.9	36.8		
	Loss	31	5.1	41.9	78	Loss equivalent to 57.6% CO_2 and 20.4% CH_4
VII	Bituminous coal..	18.1	1.2	82.2	22	
	Percentage	82.2	5.5	12.3		
	Loss	14.8	4.01	39.45	58.3	Loss equivalent to 54.24% CO_2 and 4.01% H oxidized
VIII	Bituminous coal..	34.3	2.29	5.15	41.7	
	Percentage	82.2	5.5	12.3		
	Loss	4.3	3.3	37.9	45.5	Loss equivalent to 15.7% CO_2 and 29.8% H_2O
IX	Bituminous coal..	44.8	3	6.7	54.5	
	Percentage	82.2	5.5	12.3		
	Loss	34.57	6.03	43.95	84.55	Loss equivalent to 60.79% CO_2 and 24.12% CH_4
X	Anthracite	14.53	.27	.65	15.45	
	Percentage	94.04	1.75	4.21		
	Loss	16.17	5.7	43.12	64.99	Loss equivalent to 59.29% CO_2 and 5.7% H oxidized
XI	Anthracite	32.93	.6	1.71	35.01	
	Percentage	94.06	1.71	4.23		

It is seen from the table that the conversion of woody tissue to peat, lignite and bituminous coal may be brought about in three distinct ways and the change to anthracite may take place in two ways with little or no chemical action between the woody fiber and outside material. The probable stages in the change are indicated in numbers I, IV, VII and X.

By reference to this table it will be seen that peat and lignite are almost identical, and that the peat is somewhat more decomposed than the lignite. This, however, is not necessarily so, for the upper layers of a bed of brown coal may show peat, which in all probability would not have reached the same degree of decomposition as the coal beneath. This gradation from peat to brown coal or lignite is shown in a deposit of brown coal at Grovetown Ga.

---

[1] Bischof, Gustav. Elements of Chemical and Physical Geology. 1:276–80. Tr. by B. H. Paul & J. Drummond.

From this table it will be seen that the change from wood and moss to lignite and peat consists in the evolution of certain percentages of carbon, oxygen and hydrogen, which leaves a relatively increased percentage of carbon and a decreased percentage of hydrogen and oxygen. The principal products given off in this change are marsh gas, carbon dioxid and water. Some nitrogen is given off; but this may ordinarily be neglected on account of the small amount present, and in cases where large quantities may be found, it is probably due to the decomposition of animal matter or to the ammonia that is brought down by rains. Analyses of the gas given off from peat beds do not give data that can be depended on in determining the formation of peat. The evidence of this is shown by a comparison of the analyses of sphagnum, compact peat and the gas from a peat bed as analyzed by Websky.[1]

Composition exclusive of ash

	Carbon	Hydrogen	Oxygen	Nitrogen
1 Sphagnum	49.88	6.54	42.42	1.16
2 Peat	50.33	5.99	42.63	1.05
3 Peat	50.86	5.8	42.57	.77

1 Sphagnum moss from a bog at Grunewald near Berlin.

2 Peat from same place.

3 Peat from the high moors (Hochmoor) of the Upper Harz, 2500 feet above the North sea.

The analyses of the gas from a peat bed by the same authority gives CO_2 2.97; CH_4 43.36 and N 53.67.

Now, granting that only half the original material in the sphagnum had been evolved as gas, it will readily be seen that such a percentage of nitrogen as the result of the decomposition of vegetable matter is an impossibility, for the peat contains nearly all the original nitrogen of the plants, or its place has been taken by nitrogen washed in by rains. Again, though the decomposition is largely a process of deoxidation, and a much smaller percentage of CO_2 is given off than is the case when the vegetation decays under ordinary conditions, yet the small percentage of this gas given is probably incorrect, for water takes up its own bulk of carbon dioxid, while only about 5% of its bulk of marsh gas is taken up by water. It will thus be seen that the tendency is for the CO_2 to be dissolved in the water and taken from the water by Mollusca, while the marsh gas is thrown off into the air. In this way the small percentage of CO_2 in the gas from a bog may possibly be explained. In addition, we must account for the disappearance of a large percentage of oxygen, which can not be accounted for in any other way than by supposing that the amount of CO_2 formed is greater than is indicated by the analyses given above.

---

[1] The foregoing is quoted from Percy's *Metallurgy*, where the following reference is given: Websky, Justus. Erdmann's Journal für Praktische Chemie. 1864. 92:98.

Analyses of peat

The composition of peats from various places is shown in the following table of analyses:

Chemical composition of peat

SOURCE	Org.	H_2O	Fe_2O_3 and Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	CO_2	SiO_2	Cl	Ins.	Authority
Michigan:														
Meare near Bridgewater.....	97.78	.....	.536	$CaCO_3$ .855	.144	.131	.065	.053	.051	....	.403	....	.....	Mich. Agric. Rep't 1865. p.208
New Jersey:														
1 Black brook meadows, Columbia turnpike, Morris co.	65.61	16.16	3.19	3.86	.37	.31	.....	.93	.89	.09	8.64	....	.....	Geol. of N. Jersey. 1868. p.481
2 Peat cut for fuel at Columbia, Morris co., 2 to 3 feet below surface............	66.87	15.15	3.97	3.17	.39	.27	.....	.1	2.46	....	7.63	....	.....	Geol. of N. Jersey. 1868. p.481
3 Allandale bog in Bergen co.	83.8	11.7	.42	1.46	.17	.08	.....	.05	.74	.04	1.07	....	.....	Geol. of N. Jersey. 1868. p.481
4 Beavertown, Morris co.....	69.8	16.8	2.92	3.34	.27	.02	.....	.19	.76	.43	5.36	....	.....	Geol. of N. Jersey. 1868. p.481

Rhode Island peats[1]

		H_2O	Ash	Vegetable matter	SiO_2	Fe_2O_3 Al_2O_3	CaO	MgO	K_2O_2 loss	
1 Cranston	......	......	13	87	8	2.2	2.8	.....	tr.	
2 Block Island	......	25.25	6.35	68.4	4.5	.75	1.1	.....	.....	
3 Bristol	light and porous	......	13.9	86.1	......	......	.....	.....	.....	
4 Cumberland	......	......	76	24	69.8	3.2	.5	.8	.....	
5 Cumberland Hill	light, flaky and fibrous, color brown	......	2.15	97.85	.45	.25	1.8	.....	1.5	
6 N. Kingston	compact, red brown	......	25.6	74.4	21.2	2.4	1.5	.....	.5	
7 N. Kingston	heavy	......	65	35	57.6	.5	5.5	.....	.....	
8 S. Kingston	ashes mostly silica	......	62.5	37.5	......	......	.....	.....	.....	
9 S. Kingston	gravelly, rather heavy and fine	......	48.4	51.6	41.85	4.2	1.2	.8	.....	
10 S. Kingston	......	......	10.5	88.5	7	1.5	.6	.....	.....	1.2 phosphate of lime
11 Cranston	......	......	7.9	92.1	6.3	.9	.7	.....	.....	
12 Pawtucket	......	......	11.4	88.6	9.5	1.9	.....	.....	.....	
13 Wickford	......	15.9	11.5	72.6	8.9	1.5	1.1	.2	.....	
14 Woonsocket	......	10	1.8	88.2	.5	.8	.6	.....	.....	
15 Warwick	......	13.5	49	37.5	40.7	5.1	3.2	.....	.....	
16 Warwick	......	......	4	96	......	......	.....	.....	.....	
17 Wickford	......	......	12	88	......	......	.....	.....	.....	
18 S. Kingston	......	......	17.5	82.5	12	2.1	2.5	.5	.4	
19 Pawtucket	......	......	32.5	67.5	......	......	.....	.....	.....	
20 Warwick, Pottwoomet	......	......	10.5	89.5	......	......	.....	.....	.....	
MASSACHUSETTS										
21 Lexington	......	26	69	69	.1	.6	.....	.....	tr.	3 phosphate of lime

---

[1] Jackson, Charles T. Report on the Geological and Agricultural Survey of the State of Rhode Island. 1840.

Additional analyses

SOURCE	H_2O	Ash	Organic matter	Authority
1 Bedford N. H.......	......	7	93	Analyses 1–8 are taken from *Geology and Mineralogy of the State of New Hampshire*, 1844, by Charles T. Jackson.
2 Bedford N. H.......	5.8	4.6	89.6	
3 Canterbury N. H....	......	6.2	93.8	
4 Canterbury N. H....	13.7	23.4	62.9	
5 Lyndeborough N. H.	21	12.3	66.7	
6 Franconia N. H.....	......	26.3	73.7	
7 Merideth N. H......	......	5.1	94.9	
8 Bedford N. H.......	......	24.3	76	
9 St Dominique Can..	......	7.27	92.73	Geology of Canada, 1863.
10 St Dominique Can..	......	6.75	93.25	
11 Rochester N. Y. ...	14.47	2.15	83.38	Fairchild, H. L. & Barnum, E. G. Pinnacle Peat Marsh, Proc. Roch. Acad. of Sci., v.3. Edward Hirschfield, analyst.
12 Rochester N. Y.....	14.23	3.05	82.72	
13 Rochester N. Y.....	14.51	5.08	80.41	
14 South Salem N. Y..	19.43	21.27	59.3	R. A. Fisher, analyst.
15 Ardennes, France...	30.5	8.3	61.2	M. Diday, analyst, quoted from Taylor's *Statistics of Coal*.

Connecticut peats[1]

SOURCE	Analyst	Org.	Ash	Water	Place
1 Goshen Ct........	E. H. Twining	52.42	35.21	12.37	Fresh-water swamp
2 Goshen Ct........	"	71.67	8	20.33	"
3 Goshen Ct	"	80.35	4.52	15.13	"
4 Milford Ct........	"	77.1	3.23	19.67	"
5 Milford Ct........	"	84.4	2	13.6	"
6 Plainville Ct......	"	52.1	29.2	18.7	"
7 Griswold Ct......	"	52.45	34.7	12.85	"
8 Berlin Ct.........	"	69	13.59	17.41	"
9 Colebrook Ct.....	"	57.05	4.57	38.38	"
10 West Cornwall Ct.	"	65.4	14.89	19.71	"
11 North Granby Ct.	"	41.16	47.24	11.6	"
12 Poquonnock Ct...	"	76.03	5.92	18.05	"
13 Poquonnock Ct...	"	74.17	8.63	17.2	"
14 Brooklyn Ct......	"	76.45	7.67	15.88	"
15 Brooklyn Ct......	"	77.52	9.03	13.45	"
16 Brooklyn Ct......	"	23.88	67.77	8.35	"
17 Brooklyn Ct......	"	60.1	25.78	14.12	"
18 Collinsville Ct....	R. A. Fisher..	31.03	57.78	11.19	"
19 Collinsville Ct....	" ..	15.41	50.01	34.58	"
20 Collinsville Ct....	" ..	13.68	29.21	57.11	"
21 New Haven Ct....	" ..	52.02	36.52	11.46	Salt marsh
22 New Canaan Ct...	" ..	23.81	68.9	7.29	Fresh-water swamp
23 New Canaan Ct...	" ..	23.88	70.16	5.96	"
24 New Canaan Ct...	" ..	26.44	66.9	6.66	"

---

[1] Johnson, S. W. Essays on Peat, Muck and Commercial Manures.

Connecticut peats (*concluded*)

SOURCE	Analyst	Org.	Ash	Water	Place
25 Rockville Ct.	R. A. Fuller	64.23	5.41	30.36	Fresh-water swamp
26 Rockville Ct.	"	83.88	2.21	13.91	"
27 Rockville Ct.	"	52.16	9.63	38.21	"
28 Brooklyn Ct.	"	55.05	6.37	38.58	"
29 New Haven Ct.	"	57.57	27.13	15.3	"
30 Stonington Ct.	"	64.81	8.68	26.51	Originally fresh, now covered with salt water
31 South Salem N. Y.	"	59.3	21.27	19.43	Fresh-water swamp
32 Salisbury Ct.	"	55.23	16.7	28.07	"
33 Stonington Ct.	"	28.37	61.85	8.78	Salt-water swamp

Ontario peats[1]

BOG	Water in original sample	Calculated on 15 % water content		
		Volatile combustibles	Fixed carbon ash	
	Per cent	Per cent	Per cent	Per cent
1 Welland				
From top to 20 in. depth	82 2	59.27	21.66	4.07
From 20 in. to clay bottom at 42 in.	87.48	56.78	21.05	7.17
2 Beaverton				
From top to 7 in. depth	62.98	57.13	11.67	16.2
From 7 in. to 15 in. depth	83.81	67.58	10.39	7.03
From 15 in. to 26 in. depth	84.86	73.6	4.72	6.68
From 26 in. to 40 in. bottom	82.98	56.93	.40	27.67
3 Perth				
Top 5 ft.	....	54.72	19.85	10.43
Top 4 ft.	....	57.81	18.92	8.27
4 Brunner				
Top 3 ft.	....	60.1	15.7	9.2
5 Brockville				
Upper stratum, 3 ft.	....	55.08	20.62	9.3
Part lower stratum, from 3 down to 5 ft.	....	57.15	13.73	14.12
6 Rondeau				
Lower stratum beneath surface growth	....	58.56	23.29	3.15
"	....	54.6	22.44	7.96
From stock pile	....	67.99	11.06	5.95
7 Newington				
Sample no. 1	87.94	56.74	27.21	1.05
2	86.66	54.42	28.61	1.97
3	87.62	58.70	24.73	1.57
4	90.12	58.15	25.3	1.55

[1] Carter, W. E. H. Peat Fuel: its Manufacture and Use. p.18.

Analyses of Irish peat[1]

SOURCE	Carbon	Hydrogen	Oxygen	Nitrogen
Philipstown, surface peat	58.694	6.971	32.883	1.4514
Philipstown, dense peat	60.476	6.097	32.546	.8806
Bog of Allen, surface peat	59.92	6.614	32.207	1.2588
Bog of Allen, dense peat	61.022	5.771	32.4	.807
Twichnevin, surface peat	60.102	6.728	31.288	1.8866
Shannon, surface peat	60.018	5.875	33.152	.9545
Shannon, dense peat	61.247	5.616	31.446	1.6904

[1] Dublin Journal of Industrial Progress. Ash and moisture not given.

Methods of determining fuel value

Though these analyses do not show the exact value of the materials for fuel or for fertilizer, they may be used as a standard of comparison and indirectly assist in determining the fuel value; but for accurate results the only method of determining the fuel value is by using a calorimeter. In determining the value of peat as a fertilizer, it is doubtful whether any of these analyses are of any value, as the benefit derived from peat depends not so much on the chemical composition as on the mechanical effect on the soil and its property of absorbing ammonia. In determining the value of fuels, it is necessary to have a unit of measurement; and in England, the United States and among most English-speaking people this standard is the British thermal unit, while in France and Germany the standard unit is the calory.

Inasmuch as fuels are composed for the most part of carbon and hydrogen, it has been agreed in the scientific and commercial world that all the carbon must be burned to carbon dioxid and all the hydrogen must be burned to water in determining the value of any fuel. The sulfur and nitrogen are ordinarily neglected in these determinations. The amount of heat absorbed by a unit of pure water when its temperature is raised 1° F. is known as the British thermal unit. Ordinarily the unit of water is the pound; and, as heat and dynamic energy may be considered convertible, the value of the fuel in foot pounds may be obtained by multiplying the number of British thermal units by 772. The calory is the quantity of heat absorbed by a unit of pure water when its temperature is raised 1° C. Both the gram and the kilogram are used as the unit weights of water.

An approximation of the result obtained by direct determination in a calorimeter may be obtained from the ultimate analysis of the fuel by the following formula, which gives the value as compared with pure carbon.

$$V = C + 4.25 \left(H - \tfrac{1}{8} O\right)$$

where

C=percentage of carbon
H= " hydrogen
O= " oxygen

In this case the amount of carbon, hydrogen and oxygen in the fuel must be known, though the sulfur and nitrogen may be neglected on account of the small amount present in most cases. It will be seen that the only analyses in the tables given above that can be used in calorimetric determinations by this method are those of Irish peat quoted from the *Dublin Journal of Industrial Progress*. Some authors hold that the heat value of a fuel may be determined more accurately by using a proximate analysis; but this is doubtful, though in the case of peat a close approximation might be obtained in dry fuel. If the volatile matter were all marsh gas, the proximate analysis would do as well as the ultimate analysis; but the presence of other volatile matter complicates the computation. Another method of determining the heating power of a fuel is by mixing a given weight of the fuel with a quantity of litharge and heating the mixture in a crucible; the heating power is in proportion to the quantity of lead reduced. Experiments made by Mr C. Cowper gave the following results.[1]

10	grs. of	Newcastle coal	284	grs. lead
10	"	oven coke	302	"
10	"	common peat, Bog of Allen	144	"
10	"	same coked in crucible	259	"

---

[1] Taylor, R. C. Statistics of Coal. Phila. 1848. p. 385.

From this it would appear that 2 tons of peat are equal in fuel value to 1 ton of Newcastle coal.

PART 3

Economic value of swamps

In addition to peat, many valuable materials are found in greater or less abundance in different swamps; and some of the more valuable of these and their uses are mentioned with the discussion of the uses of peat.

Timber. The first product that is of utility in many of the swamps is the large supply of timber. Many of these tracts are covered with a dense growth of white cedar, while others furnish large quantities of maple, birch, elm and ash. The growth of trees is so rapid that with a little care a continuous supply of good timber might be secured. For such a use of the swamps, only the wood that has reached its maturity should be cut, thus allowing the half grown trees to become of value. The usual practice of cutting every tree, whether large or small, greatly depreciates the value of any swamp as a timber producer.

Marsh grass and cat-tails. Large crops of marsh hay are taken from some of the salt marshes, and this material finds a good market as a packing material. In some swamps the growth of cat-tails is so luxuriant that they are cut and prepared for use in tight cooperage.

Moss litter. In sphagnum swamps two kinds of peat are generally recognized, the light, fibrous, undecomposed upper layers known as fibrous peat and the compact, pulpy lower layers which are more thoroughly decomposed and form the peat proper. The upper portion, which consists of matted roots and dead mosses and grasses, is often known as moss litter. Decomposition has not advanced to such a stage that the vegetable fibers have lost their strength; and, on account of its strength and property of absorbing large quantities of liquids and gases, it is extensively used in various industries both in this country and Europe. Usually the moss litter does not extend for more than two feet below the surface, though in swamps that are in colder climates the decomposition may never begin.

The principal purpose for which moss litter is used in this country is for packing trees and plants for shipment. The amount that is used in this way is very great, though the extent of its use is not realized because the gathering and preparation of the litter are not carried on as a regular industry, but each nurseryman sends his own men in slack times to the swamps to obtain the year's supply.

The preparation of the moss for this purpose consists merely in digging blocks of the material and air-drying them on the surface of the bog before hauling them away. When it is used for packing, it is pulled apart so as to make it light and fluffy. No particular care is used to get rid of the small sticks that may be present, though large pieces of wood are thrown out. In Sweden and Germany it has been used for some time in stables as bedding on account of its absorbing such large quantities of moisture and gases. It is now used to a slight extent for the same purpose in the larger cities of this country.

In several places in Canada this litter is prepared as an article of commerce, and in this case all the sticks are removed, and the moss is dried.

Peat fuel

The use of peat as an article of fuel has been known in European countries from the beginning of the Christian era, and the early references to its use would indicate that it had been employed for a long time before that. Pliny, in his *Natural History*, relates that "the Chauci pressed together with their hands a kind of mossy earth which they dried by the wind rather than the sun, and which they used not only for cooking their victuals, but also for warming their bodies." During the Middle Ages frequent references to its use were made in leases and other documents, but the great increase in its use came with the invention of the steam engine and the demand for cheap fuel for generating power. Up to that time the only use for peat and other fuel was for domestic purposes, and the method then used and still employed to a large extent in preparing peat for fuel consists of cutting the peat from the bog in rectangular blocks and spreading these blocks on the surface of the bog to dry. When the greater part of the moisture is dried out, the blocks are stacked up like bricks, so that the wind has free access to all parts. When thoroughly air-dried, this fuel contains in many cases 20% of moisture, so that the full fuel value can not be obtained in burning it because of the amount of heat necessary to drive off the moisture.

Peat prepared in this manner, though ordinarily taken from the lower part of the deposit, is bulky and under the best conditions will not yield more than five ninths as much heat as is generated from the same weight of anthracite coal, which is about the same result as is obtained by the use of wood, as will be seen by reference to the following tables. These show in the columns marked A the number of pounds of lead reduced from litharge by 1 pound of the respective fuels and in the columns marked B the number of pounds of water raised from 32° F. to 212° F. by 1 pound of fuel.

	Partially dried Berthier		Containing 9% water Winhler		Perfectly dry Schodter and Peterson
	A	B	A	B	B
Oak	12.5	28.3	14.05	31.82	39.82
Ash	....	....	14.96	33.89	39.76
Sycamore	13.1	29.7	14.16	32.07	40.85
Beech	13.7	31	14	31.71	39.44
Birch	14	31.7	14.08	31.9	39.73
Elm	....	....	14.5	32.84	41.55
Poplar	....	....	13.04	29.54	40.72
Lime	....	....	14.48	32.8	41.87
Willow	....	....	13.1	29.67	39.61
Fir	14.5	32.8	13.86	31.39	41.25
Pine	13.7	31	13.88	31.44	40.82
Scotch fir	....	....	13.27	30.06	46.85
Hornbeam	12.5	28.3	.....	.....	.....
Alder	13.7	31	.....	.....	.....
Larch	....	....	.....	.....	41.25

	A	B	
Peat from Ham, dep't of Somme....	12.3	27.9	Berthier
" Possy, dep't of Marne.....	13	29.2	"
" Framont, dep't of Vosges..	15.4	34.9	"
" Königsbrunn, Wurtemburg	14.3	32.4	"
" Bog of Allen............	14.4	....	Cowper
" Bog of Allen, pressed.....	13.7	....	Everitt
Coppage turf	13	....	Kane's Indus. Resources of Ireland
Kilbeggan turf	14.2		
Kilbaha turf	13.8		
Peat from Ischomx	15.3	34.6	Berthier

	A	B	
Peat charcoal from Bog of Allen, upper....	27.7	....	Everitt
" Bog of Allen, lower.....	25	....	"
" Essone	22.4	50.7	Berthier
" Ham	18.4	41.7	"
" Seine	17.7	40.1	"
" Framont	26	58.9	"
Pennsylvania anthracite	30.5	69.1	"

In order to reduce the bulk and the amount of water, many machines have been invented for milling the peat. This does not increase the heating power of a given weight of peat that is free from water, but is useful in intensifying the heat and simplifying the transportation problem by reducing the bulk of the peat and the amount of water. Most of the peat that is used for manufactures in Europe is compressed, and many attempts have been made to introduce compressed peat into general use in the United States and Canada. Though peat briquets are cleaner than most fuels, their use must of necessity be limited to localities near the deposit on account of the expense of transportation. If, however, the peat is charred or coked, and the peat coke briquetted, we have a fuel which is nearly if not quite equal to anthracite coal, though heretofore the expense of coking has been so great as to prevent its use.

Methods of preparing peat for fuel. The methods of cutting and preparing peat for fuel are many and varied, and the following description of the processes used is a condensation of articles by Percy, Mason, Dal and Carter.

Extraction of peat.[1] "Peat is usually of such consistency that when the bog in which it occurs admits of being suitably drained by the cutting of trenches or otherwise, or does not require artificial drainage at all, it can be extracted by hand with the use of simple and appropriate tools; and, for the most part, it has been so extracted from time immemorial.

"Peat, in being extracted by hand, is cut into prismatic pieces, which will be designated by the word peats. The superficial covering of living, or only slightly decomposed, coarsely fibrous vegetable matter must be pared off and thrown aside, as it is comparatively valueless for fuel. A straight trench with vertical sides, and a convenient length, breadth and depth, is dug in the parts so cleared, after which the peat may be cut from each side vertically downward, which is the usual course, or horizontally and parallel to the trench. The peats are carefully removed and arranged so that they may be gradually air-dried.

"It is obvious that the thinner peats are cut, the more quickly will they dry. It is stated that in Bavaria much of the peat there used for locomotives is less on an average than 2 inches in thickness."

Cutting peat by hand in Hanover.[2] The bog having been drained by simple trenching, "the peat is gotten in lengths 10 feet wide and from 100 to 1000 paces long, excavated crosswise, i. e. in the direction of the width, so that the working face is 10 feet broad. It is wholly extracted, either in one working or, if the bed be too thick for that method, in one or more successive courses. Usually only one length of the dimensions given is cut in a year from the same bog. Five workmen are employed, whose labor is distributed as follows. One man, the clearer, removes with a spade, a layer about 2 inches thick, which has been weathered by atmospheric action. Two men, the cutters, are engaged in cutting the peat, of whom one stands on the top and thrusts straight down a long-handled, heavy, iron tool, which cuts sods 17 inches long and 5 wide, whilst the other, standing underneath, using a light wooden spade pointed with iron, cuts the peat horizontally of the thickness of 5½ inches and conveys it on a board to the margin of the trench; and from time to time these men change places with each other. A fourth man, the barrow-loader, takes the peats where they are left by the cutters, and, with the assistance of the first man, piles them in wheelbarrows. The fifth man, the barrow-wheeler, with the help of the first, wheels away the peats and by simply upsetting the barrow, arranges them in rows for draining and drying, over the surface of the bog on one side of the trench, previously cleared and prepared for that purpose. The peats, having been left for a certain length of time on the drying ground, are carried away by women and gradually built up by them in high wall-like rows, care being taken to let one row become somewhat dry before another is piled upon it. In ordinary weather the peats so arranged are left to dry further for about a month; and, when they appear to be dry, but when in reality they are only about half dry, they are either carted from the bog to be stored up in magazines or piled up in large stacks on the bog itself, and there left to be further air-dried."

---

[1] Percy, John. Metallurgy. p. 220.

[2] Percy, John. Metallurgy. p. 220–22.

Cutting peat by hand in Ireland.[1] In Ireland, the universal practice is to use a " slane " or peat spade. The cutting part is of wrought iron and the handle is about four feet long. " The peat is cut by thrusting the slane vertically downwards, by pressing the foot upon the lateral projecting piece of the handle. With a slane of this kind, an able-bodied man will cut about 15 cubic yards of peat daily. He cuts and flings as many peats as will keep two boys or girls employed in catching. The peats or sods are then put into barrows, and wheeled to the nearest convenient spot where they may be placed to dry."

---

[1] Percy, John. Metallurgy. p. 224.

Brosowsky's peat-cutting machine.[1] "In North Prussia a peat-cutting machine has been employed which has the great advantage of being able to cut and raise the peat from a depth of 20 feet or more: by means of which, peat, covered by a considerable depth of water, may be utilized without the expense of draining. It consists essentially of a cutter, made like the four sides of a box, but with oblique edges, which is forced down into the peat to the required depth. A spadelike blade is then driven under the cutter by means of levers, whereby the long rectangular prism of peat is cut off at the bottom, and the apparatus is then raised. The prism is afterward cut up into convenient sized blocks by means of the blade."

French peat-cutting machine.[2] A machine, having the same object as that of Brosowsky, is stated to have been invented in France about the middle of the 18th century by Eloi Morel. Other machines are used in France but the author has been unable to secure a good description of them.

Dredging peat. In some localities where the peat is in a more or less mudlike state, so that it will not hold together when dug by hand or machine, dredging machines have been used. In Holland the peat has been dredged in bags fastened to iron rings, so that the water will drain through the bags, after which the partially drained mass is laid on drying ground to become thoroughly air-dried.

Mechanical treatment of peat.[3] Common peat, when cut from the bog either by hand or by machine, is so tender and easily broken that it will not bear shipment to any distance. Even if it had the necessary coherence, it is so bulky compared with coal, that its use would compel the construction of larger and more costly furnaces in case it were used for metallurgic purposes. Many attempts have been made to obviate the difficulties which ordinary air-dried peat presents, and the principal methods employed may be classified as follows: (1) condensation of raw peat by compression; (2) condensation of air-dried peat, cold, by compression; (3) condensation of air-dried peat, hot, by compression; (4) condensation of raw peat by pulping, molding and air-drying or drying by artificial heat, with or without compression; (5) coking.

---

[1] Percy, John. Metallurgy. p. 225.
Dingler's Polytechnisches Journal. 1865. 176:336.

[2] Percy, John. Metallurgy. p. 226.

[3] Percy, John. Metallurgy. p. 227-29.

1 Condensation of raw peat by compression[1]

Many presses for the compression of raw peat have been constructed from time to time, but they have generally proved failures from an economic point of view.

"The earliest kind of machine for compressing raw peat, that is, peat as it comes wet from turbary, was very simple and consisted of a rectangular frame fitted with a flat piston which might be strongly depressed by a lever or otherwise, provision being made for the escape of water from the peat during its compression. A patent was granted in 1839 to Lord Willoughby de Eresby for a machine constructed on that principle.[2]" It is reported that Pernitzsch compressed peat in Saxony so long ago as 1821.

Schafhäutl's press with rotary motion.[3] "The first peat-compressing machine with rotary motion was said to have been invented by Schafhäutl. Compression was effected by placing the peat in frames fixed on an endless chain passing between a pair of rolls, set a certain distance apart, grooved rectangularly in the direction of their axes, which were horizontal and in the same vertical plane."

Compression by rolling.[4] About 1860, loose textured fibrous peat was reduced to about one third its original bulk by being passed through iron rolls at Neustadt in Hanover. Before rolling, the peat was cut into sods of uniform size, and the product burned much more regularly than air-dried peat.

---

[1] Percy, John. Metallurgy. p. 230.

[2] Johnson, S. W. Peat and its Uses. p. 116.

[3] Percy, John. Metallurgy. p. 230.
Vogel, August. Der Torf etc. p. 80.

[4] Johnson, S. W. Peat and its Uses. p. 119.
Percy, John. Metallurgy. p. 237.

Mannhardt and Koch's press.[1] "The principal feature" of Mannhardt and Koch's press, "consists in the use of a pair of large horizontal rolls covered with cloth to serve as a filter. On the circumference of the roll, ribs of hoop iron are fixed obliquely about 1 inch apart, which support drilled iron plates surrounded by an endless band of cloth. The wet peat is torn to pieces and put into two hoppers, one over each roll, whence it is drawn by rake rollers and laid equally upon the cloths moving with the rollers; but in its course to the large rolls, it passes through a series of three small rolls, fixed above each large roll, whereby it is deprived of most of its water. There are thus two streams of peat descending from the two hoppers and passing first through a pair of small rolls, then through a pair of spiked rolls, and lastly through the two large rolls, by which the remaining water is pressed through the remaining filter cloth into the interior of these rolls. The peat now forms a compact sheet, which is conveyed to a knife-like apparatus, which divides it transversely, and then to circular cutters, which divide it longitudinally into blocks of the required dimensions. The peat is thus freed from water to such an extent that its further desiccation may be effected in favorable weather in the course of a few days under covered airy sheds, or in unfavorable weather, by artificial heat in suitable apparatus."

2 Condensation of air-dried peat, cold, by compression[2]

About 1859 a process of condensing air-dried peat was in vogue in Lithuania, which consisted in disintegrating and air-drying the peat by plowing and harrowing the surface of the bog, after which the pulverized peat was rammed in a mold by a stamp weighing about 200 pounds. This process does not seem to have been generally adopted and may be considered as an experiment so far as the preparation of fuel on a large scale is concerned.

---

[1] Percy, John. Metallurgy. p. 231.
Vogel, August. Der Torf etc. p. 81.

[2] Percy, John. Metallurgy. p.232.

3 Condensation of air-dried peat, hot, by compression

Exter's process.[1] "This process, it is asserted, has been brought to the highest degree of perfection in a large and costly establishment between Munich and Augsburg where there is an extensive range of peaty moorland known as Haspelmoor. The moor is worked in rectangular plots 3000 feet long and 1500 feet broad, which are pared and then flattened, so that the water may drain from the center toward each of the four sides of the plot into the surrounding trenches, care being taken that no depressions are left in which rainwater might collect and form puddles. The surface is plowed to a depth of 2 or 3 inches, and the peat so turned up is disintegrated by raking it over two or three times with wooden rakes. In sunny and windy weather the peat becomes so dry that in the course of two or three hours it will no longer cohere by pressure, though it still retains from 30% to 40% of water; and, when sufficiently dry, it is heaped together in small stacks, to be ready for conveyance to magazines near the works. When brought to the mill, the peat is put into a bolting machine. The fine peat drops through, while the coarse, which consists of lumps and pieces of wood, falls out at the lower end and is used as fuel for raising steam. The fine material is heated to 100 degrees C., and pressed while hot into blocks. The press consists essentially of a box open at both ends, of the same form and area in cross-section as the largest side of a peat block and is fitted with a piston which is moved horizontally by means of an eccentric. When the piston is withdrawn to the fullest extent, hot peat drops into a channel between the piston and the mouth of the box and is pushed into the box and compressed by the forward movement of the piston, block after block being quickly formed and thrust out at the opposite end of the box."

4 Condensation of raw peat by pulping, molding and air-drying or drying by artificial heat, with or without compression

Challeton's process.[2] "Works for carrying out this process were erected in 1854 by M. Challeton at Montauger near Corbeil.

---

[1] Percy, John. Metallurgy. p. 233-36.

[2] Percy, John. Metallurgy. p. 237-40.

The peat, which is extracted by cutting or dredging, is conveyed to the works in boats by canals in the turbary and put into a tank lined with boards and deepening at the bottom toward the center. The peat is thence raised by a chain of buckets to the hopper of the dividing apparatus, which consists of a series of cylinders 4 feet long, but differing in diameter, fitted with knives 4 inches long and 1½ inches thick. These cylinders rotate and tear up the peat, which is next ground in a mill with conical surfaces like a coffee mill, after the addition of sufficient water. Between the cylinders and the conical mill is a sieve with brushing apparatus which retains filaments and grosser particles and allows the rest of the peat, now in a mudlike state, to pass through. The muddy liquid falls into tanks, where it is agitated by a shaft carrying arms, while a stream of water keeps flowing in at the bottom, and the muddy mixture is removed to a certain depth from the surface by a chain of buckets and poured into a wooden trough communicating with filtering tanks. Heavy materials such as sand, fall to the bottom during the agitation and are thrown away." After four or five hours, most of the water is removed from the peat in the filtering tanks, and the soft material can then be divided into blocks in exactly the same manner as in the original bog.

Weber's process.[1] At the works of Maffei & Weber at Staltach in Bavaria, " the peat is cut in pieces of about a cubic foot, worked into pulp, molded without compression into brick-shape pieces, or bricks, as they are termed, and dried under cover, first by simple exposure to the air, but afterwards by artificial heat. A gradual contraction in drying gives the peat the aspect of compressed peat and it is in no wise inferior to it, either in tenacity or compactness.

The peat is reduced to homogeneous pulp in a mill consisting of a vertical, sheet-iron cylinder, 4 feet high and 3 feet in diameter, open at the top, in which rotates a vertical shaft carrying eight blades. The blades are curved, triangular in cross section, and sharp at the convex edges for the purpose of cutting the peat. When the peat is too dry for pulping, water is added. Pulping in this process is effected by cutting and not by rubbing, as in Challeton's machine.

---

[1] Percy, John. Metallurgy. p. 240–44.
Dingler's Polytechnisches Journal. 158 : 272–86.

"The pulp is molded either in molds such as are used for making mud brick, or the pulp is put into pits where the water drains off, and the peat is then cut into the required dimensions. After being either molded or cut, the peats are air-dried and then desiccated in a large building by artificial heat."

Linning's process.[1] In 1837 a patent was granted to Linning "for the preparation of peat by pulping, compressing and molding." The pulping was accomplished in a pug mill similar to those used in making brick, but fitted with longer and sharper knives. The peat was then molded like brick and pressed, after which they were dried either in the air or in kilns.

Buckland's peat machine.[2] This machine "consisted of an obtuse iron cone having a spiral groove on its exterior and revolving vertically and concentrically with the apex downward within a hollow cone of iron plate perforated everywhere with small holes like a colander. The peat was put into the space between the solid and hollow cone and, by the rotation of the former, was squeezed through the holes in the latter and extruded in the form of wormlike pieces; as prepared, it was ready for molding, and compressed peat bricks were artificially dried."

Schlickeysen's peat machine.[3] This machine has been used in Germany since about 1860 and with its many improvements is probably used more at the present day than any other one machine. "The peat is pulped in a vertical cylinder, in the axis of which a shaft rotates carrying projecting blades which are strong and have cutting edges, and are so placed as to force down the peat. The blades are arranged nearly but not exactly, in a true spiral, the effect of which is that they act unequally on the mass and mix and divide it more perfectly. There are no blades or projections fixed to the internal surface of the cylinder. The pulp is driven out sideways through one or more nozzles inserted close to the bottom of the cylinder and issues in the form of a continuous block or pipe, that is cut off in suitable lengths either by hand or by machine. The addition of water is unnecessary in any case, indeed the pulp may with advantage be previously air-dried."

---

[1] Percy, John. Metallurgy. p. 244.

[2] Percy, John. Metallurgy. p. 245.

[3] Dingler's Polytechnisches Journal. 1862. 165:184 and 1864. 172:336.
Percy, John. Metallurgy. p. 245-46.
Johnson, S. W. Peat and its Uses. p. 144.

Leavitt's peat-condensing and molding mill.[1] About 1867, Mr T. H. Leavitt, of Boston Mass., took out a patent on a peat-condensing mill which consisted "principally of a strong box or cistern 3 feet in diameter and 6 feet high." The upper portion of the box is divided by a series of horizontal partitions, the upper ones being open latticework and the lower ones being perforated with numerous holes. The upright shaft which rotates in the center of the box, carries a series of arms or blades extending on opposite sides, and, as these revolve, they cut the peat and force it through the opening in the diaphragms. The lower portion of the box, in place of complete partitions, has a series of corrugated shelves extending alternately from opposite sides, and the peat is pressed and scraped from these by a series of arms. By this series of operations the air bubbles are expelled from the peat, and it is reduced to a homogeneous paste. When it arrives at the bottom of the box, it is still further compressed by the converging sides of the hopper, and it is received in light molds which are carried on an endless belt. Powdered peat is used for preventing the prepared peat from adhering to the mold. This prepared peat is then air-dried and is fit for use after about 10 days.

Hodge's method.[2] About 1866, a method of digging and preparing peat was devised by Mr Hodges in Canada. The plant consisted essentially of a barge, on which was all the machinery for digging and preparing the fuel. At one end of the barge were two screw augers, 11 feet in diameter, which bored out the peat in precisely the same manner as a common auger bores wood. The peat was then delivered into the barge and elevated to a hopper, from which it passed to a machine which removed all sticks and stones and reduced the peat to a pulpy mass. The pulp was then conveyed by a long spout to the surface of the bog, where most of the water drained out; when sufficiently dry, the mass was divided into blocks and stacked up to be removed, when thoroughly air-dried, to market.

---

[1] Leavitt, T. H. Facts about Peat. p. 60.
Percy, John. Metallurgy. p. 246.
Johnson, S. W. Peat and its Uses. p. 146.

[2] Geol. of Canada. 1866.
Percy, John. Metallurgy. p. 247–57.

Desiccation of peat.[1] The desiccation of peat is a subject which requires special consideration because of the difficulty of removing water by artificial means. Thoroughly air-dried peat contains not less than one fourth of its weight of hygroscopic water, which during combustion must be evaporated, thus causing a great loss in heat. When wet peat is exposed to artificial heat, the exterior dries into a hard crust which impedes desiccation and causes the mass to become fissured. When peat has been thoroughly dried, if it is exposed to the air, it will absorb so much moisture in a short time that it will be in no respect better than air-dried peat. Among the various methods for drying peat, may be mentioned those of Ekman and Welkner.

Kilns of a type similar to the one described below are reported to have been used in Carinthia and Hanover. It consisted of a chamber rectangular in plan, of which the walls were vertical and the roof arched. About one fourth of the hight from the bottom, was divided horizontally into two compartments by an arched floor, the upper compartment being intended to receive the peat, and the lower one to supply heated air. This lower compartment was connected with an adjoining fireplace on the outside of the chamber. In the wall forming the side of the chamber, opposite the fireplace, was a vertical chimney with a damper at the top which exceeded the hight of the kiln and communicated with the upper chamber. The floor between the upper and lower chambers was perforated so as to permit gases to pass through the peat stacked in the upper chamber and the opening from this chamber to the chimney permitted the escape of these gases and the moisture which was driven from the peat.[1]

---

[1] Percy, John. Metallurgy. p. 254.

Ekman's peat kiln.[2] This kiln was a model of Schlägel's and consisted briefly of a chamber of rectangular cross-section carrying a horizontal trellis work on which the peats were placed. The kiln was heated by the waste gas of an iron finery using charcoal as fuel, the blast from which first passed through a spark chamber and then was admitted into the kiln through an opening near the top. The dried peat was withdrawn through doors at the bottom. The flow of the heated gases was induced by an exhaust fan communicating with the bottom of the kiln.

Welkner's peat kiln.[3] An apparatus for drying wood, lignite, brown coal and peat by the application of hot blasts, was invented by Carl Welkner. "The apparatus is under cover and supported by four brackets inserted in brick pillars. When the hot blast is let on, the bottom being closed, it descends through openings, and then rises through the mass of overlying peat. The drying goes on interruptedly, fresh peat being put in at the top as fast as dried peat is taken out at the bottom, where it is obvious the peat must be driest."

Desiccation of peat by centrifugal action.[4] Many experiments have been made to dry the peat by centrifugal action, the theory being that the water would be thrown off and the peat retained in the machine. In practice it has been found that, except in very coarse, fibrous peat, the loss of peat was too great, as the fine material passes through the holes intended for the escape of the water.

5 *Peat charcoal or coke*[5]

Charcoal prepared from peat in the same manner as is employed in manufacturing wood charcoal is so friable and porous as to be of little use in manufacturing. It takes fire very readily and scintillates in a remarkable degree when burnt in a smith's fire, but it is so tender that it can not be transported to any distance without being reduced to powder. On this account, it is useless for blast furnaces where ordinary wood charcoal may be used, as the weight of the mass pulverizes the coke and chokes the fire.

---

[1] Percy, John. Metallurgy. p. 255.
[2] Percy, John. Metallurgy. p. 258–61.
[3] Percy, John. Metallurgy. p. 262.
[4] Percy, John. Metallurgy. p. 263.
[5] Percy, John. Metallurgy. p. 498–501.

For two or three centuries, many attempts have been made to char peat, and it is recorded that peat charcoal was made in the Harz in 1735 and successfully applied on a large scale. The earliest English patent for charring peat was granted in 1620 to Sir William St John, Sir Giles Mompesson and others, giving them the exclusive right "to charke or otherwise to converte into charkcole" every kind of coal, peat or other "combustable matter of what nature or qualetie soever the same may be, (wood onelie excepted)" for a period of 21 years. As no method of charring is specified, it is to be presumed that it was proposed to treat the peat in the same manner as wood when it is charred. About 1727 a patent was granted to William Fallowfield for the use of charred peat in the manufacture of iron.

Many experiments have been made in charring peat with the method commonly used for charring wood, but the result has always been a very friable coke.

Charring in open kilns.[1] About the middle of the 18th century, kilns of peculiar type were in use at the turbaries of Villeroi for making peat charcoal. "They were in the form of an inverted cone, on one side of which was a door about 5 feet high and 2 feet wide. Near the base of the cone an arched floor with holes in it for passage of air supported the peat, while underneath the little fire necessary for igniting the peat was placed. When the peat is sufficiently lighted, the opening communicating with the external air is closed, and the doorway built up with brick." After the kiln had been filled with peat, it was covered with earth and left to burn; gradually the whole mass would sink down, and, when no more smoke appeared, the charring was completed.

---

[1] Percy, John. Metallurgy. p. 501.

Charring in pits.[1] Peat has been charred in pits in much the same way as the Chinese process of making wood charcoal. The invention of the method as applied to peat is attributed to a Frenchman named Baillet. "The pit is described as slightly conic, 3 meters deep and 4 meters wide. Around the circumference, which is of brick, eight clay pipes lead to the bottom for supplying air to sustain combustion. The pit is closed by a movable, convex cover of sheet iron, like a common dish cover. On top is a hole fitted with a movable iron stopper, and there are four vents around the border. Below the surface of the ground, there is a pipe communicating with the upper part of the pit and with a brick tank connected with a series of vessels for the reception of tar or other condensable products. The smoke is driven through this pipe only when these products are being collected, at other times escaping through the vents in the top. The pit was filled by first leaving channels at the bottom, so that air might reach all parts equally, but after the bottom arches were formed, the peat was thrown in without particular care. After the peat was ignited, the cover was dropped over the pit and was itself covered with sod." The vents were opened at times depending on the nature of the smoke which was passing off.

Charring in ovens.[2] The friable nature of charred peat as prepared by any of the preceding methods, was attributed to defects in the method of preparing. It was supposed that, by inclosing the peat in a solid structure, these disadvantages would be avoided and a solid charcoal obtained. Various kinds of ovens were contrived from time to time to bring about the desired result, and it is stated that the first oven was invented by Lange, about 1745. This oven "consists of a chamber of iron cylindrical to about two-thirds its hight and conical the upper third. It rests upon an iron bed plate containing a rectangular opening over which iron bars are laid to form a grate. The bed plate rests upon a chamber of brickwork open at the top and in front, where it can be closed by a door; the floor of the chamber is inclined from back to front. This chamber is intended for a fireplace for wood fuel. Peats are carefully laid over the grate so as not to stop the draft upwards from the fireplace. The kiln is then filled through the top and wood fire is made in the fireplace. After the peat becomes well ignited, the fireplace is closed by an iron door. The peat gradually becomes heated to redness and shrinks about one-third in volume, fresh peat is now thrown in at the top, and this course is repeated until the entire contents of the kiln become red-hot. As soon as smoke ceases to escape, the top is covered with an iron plate and the contents of the kiln are allowed to cool." Charcoal made in this way however is found to be very brittle, and there is great loss owing to combustion of the lower part and the formation of much dust and slack.

---

[1] Percy, John. Metallurgy. p. 502.

[2] Percy, John. Metallurgy. p. 503 *et sequens.*
Percy, John. Metallurgy. p. 505.
Vogel, August. Der Torf, seiner Natur und Bedeutung. p. 117–19.

An oven for charring peat by a down draft rather than by upward draft, was invented by Hahnemann. This oven consisted of a circular shaft of brick or stone work 16 feet high and 7 feet in diameter in the clear. The walls gradually diminish in thickness from 2 feet at the bottom to 10 inches at the top. The shaft rests upon a solid foundation, the floor is somewhat arched with a convexity upwards, and on one side is an opening for withdrawing the charcoal. In the circumference of the floor is a gutter of glazed tiles, from which a glazed clay pipe passes with a slight inclination downwards through the wall and communicates with a tank for the reception of any liquid which may be condensed. On the middle of the floor stands a vertical clay pipe glazed internally, 19 feet high and 16 inches wide, and in which, near and around its base, are several holes, the total area of which should at least equal the cross-section of the pipe. Before charging, the opening at the bottom of the oven is filled up, then the shaft is filled with peats and on the top are laid twigs and charcoal which are lighted. When the peats at the top become regularly kindled, the open space around the chimney is closed, so that the smoke is compelled to descend through the peat and pass into the chimney near its base and thence rise into the atmosphere; as soon as the contents have become red-hot at the bottom of the shaft, all openings are carefully closed and luted and the oven is left to cool."

Charring in closed vessels by external fire.[1] About 1873, a coke oven, or rather a still, was invented by Lottmann of Chlumetz in Bohemia. The oven consisted of "an arched mufflelike chamber heated by two fires, one on each side, and by a third fire at one end under the floor. The central fireplace opens into a flue running under the floor to the chimney at the opposite end of the oven. In the top of this flue are inserted two siphonlike sets of cast iron pipes, of which the legs are parallel and which rise within the oven to about half its hight. Midway between the legs of each of these sets of pipes, the flue is stopped by a vertical partition, by means of which the gases from the fireplace are made to pass in their course to the chimney through all the four legs of the two siphon-like sets of pipe in succession. Provision is made for collecting liquid products evolved from the peat during its carbonization. The peat which is charred in this oven is hand-cut, air-dried peat."[2]

Manufacture of peat fuel in Canada[3]

Two methods of preparing peat fuel are at present in use in Canada, which are in reality but two applications of the same process. This process as described by Carter and termed by him "the Canadian process," consists of three steps, excavating, drying and compressing. At the Welland bog, a modification of

---

[1] Reports on the Vienna Universal Exhibition in 1873; presented to both houses of Parliament. Lond. 1874. pt 2, p. 308–10. Report on peat by Mr C. Paget.

[2] Percy, John. Metallurgy. p. 508.

[3] Carter, W. E. H. Peat Fuel: its Manufacture and Use. Ontario Bureau of Mines. Bul. 5. Toronto 1903. p. 23–35.

Exter's process is employed, which consists of plowing or harrowing the surface of the bog to the depth of about 2 inches and, when the peat has become air-dried, scraping it into ridges and then conveying in carts or cars to the mill. At the mill the peat is screened, then put through a mechanical drier, after which it is disintegrated and conveyed to the briquet machine. This press, which was patented by A. A. Dickson, depends on the principle "that, if a tube of indefinite length be fed with any material, the resistance due to friction between the material and tube walls, will gradually rise till no more can be forced in. Peat is of such a nature that, when once caused to pack in the tube, continued pressure on the material generates a rapid and great increase in the frictional resistance. For a die or tube 2½ inches in diameter a length of 1 foot will give a frictional resistance equal to a pressure of 8 tons per square inch on the punch." Difficulty has been encountered at the Welland plant from heating the die, and water jackets have been used to keep the tubes cool. The continued use of similar processes of briquetting peat in Russia, Germany and Holland, makes the difficulties here encountered seem somewhat surprising.

At the Beaverton works, the peat is excavated by a machine known as the Dobson excavator, which digs the peat and spreads it over the surface of the bog to dry. The peat is raked by hand and scraped into piles in about the same manner as at the Welland bog, after which it is taken to the mill. On reaching the mill, it is passed through a "disintegrating machine, where it is subjected to a fierce hail of blows in order to reduce the size of the fragments and destroy the minute plant cells of the peat fiber, thus permitting the remaining moisture to be more readily liberated in the drier. The machine consists of a circular sheet iron box incasing a horizontal shaft from which project radial cast iron arms about 1 foot in length; through the ends of these and parallel to the shaft, run iron rods, each suspending a roll of knob-like, cast steel fingers, 4 inches long and free to swing about the rod. The shaft makes 400 revolutions per minute, and the steel fingers, flying out radially, dash the peat fragments against a semicircular grizzly set close beneath. Through the one-sixteenth-inch spaces of this grating, the peat drops as a mixture of fine particles and dust, damp to the touch." The pulverized peat is then passed through the drier, after which it is briquetted in what is known as the Dobson press. This press employs a resistance block instead of the open tube, and it is claimed that friction is almost entirely eliminated. A large number of dies are used with each punch, so that the temperature is kept low. "The briquet is allowed to remain in the die for one cycle of the system and is then subjected to another compression by a second briquet being formed on top of it. Immediately after this, it is expelled and the second block takes its place. It is found after the first compression, a certain amount of expansion, about one-eighth of an inch in the length of the briquet, takes place, due to the escaping of the imprisoned air forced into the briquet by the descending punch, and this expansion the second compression counteracts, leaving the briquet more solid and compact. There are two punches in each machine, and for each punch a die block containing eight snugly fitting dies. The dies are heavier in the lower end where the compression takes place. The base block against which the briquets are formed, remains rigid unless for any reason the strain exceeds the working pressure, when a set of spiral steel springs on which the block rests take up excess pressure and prevent any breakage. The down-thrust of the punches is imparted by two heavy eccentrics faced with roller bearings, and with each stroke of the punch the die block is turned through one eighth of a revolution. Working in the next die to the compressing punch is the releasing punch, which expels the finished briquet, while the third receives an oil swab, which coats the inside of the die with a film of crude petroleum to lessen the friction and facilitate the expulsion of the briquet. The two punch system of the press acts reciprocally, a stroke being delivered at every half revolution of the eccentric shaft. With each down stroke, the compressing punch forms a briquet on top of the one previously made in the same die, the discharging punch expels from the next die the bottom or completed briquet, the third die receives its coating of oil from the oil swab. Power is transmitted through belting to a pulley on the pinion shaft and thence by a 5 foot gear wheel operating the eccentric shaft. The machine is steadied by a heavy fly wheel on each of these two shafts and runs quietly and with little vibration, notwithstanding the immense and sudden pressure exerted twice every revolution. It makes 50 or 51 revolutions per minute, producing 100 or 102 briquets."

Peat coke and volatile products

A plant[1] recently installed in Oldenburg, Germany, seems to solve the problem of coking peat economically. This is the invention of Martin Ziegler and is a modification of Lottmann's process. The plant consists of five kilns, in which from 10 to 12 tons of peat are coked in 24 hours, 3 tons of peat giving on an average 1 ton of coke. All volatile matter is driven out, and the coke burns without flame. The gases from the peat are utilized not only for heating the kilns but for supplying the boiler of a steam plant with fuel.

In coking the peat, oil and ammonia are driven off in addition to the gas, which is used as fuel, and they are saved and sold. If such a coking plant were run in connection with a gas plant, all the volatile matter could be used to advantage, and peat coke could be made with greater economy.

The following extract from Consular Report 1615[2] contains a description of the Ziegler method:

> Concisely stated, the Ziegler method consists in carbonizing peat in closed ovens, heated by burning under them the gases generated by the coking process itself. Such a plant is therefore self-sustaining, the only fuel required being coal or wood sufficient to heat the oven for the first charge, when the gases generated by the coking process become available and enable the operation to be repeated and continued indefinitely. Not only this, but the offheat from the retort furnaces passes on and heats the drying chambers, in which the raw, wet peat is pre-

---

[1] Dal, Adolf. Utilization of Peat Fuel in Europe. Eng. Mag. Nov. 1902.

[2] U. S. Department of State. Consular Report 1615. Ap. 8, 1903. p. 6–7.

pared for the ovens by drying to the point of economical carbonization. There is transmitted to the department as an exhibit with this report a sample of 1 kilogram (1000 grams, or 2.2 pounds) of raw peat, and the several products derived therefrom by the Ziegler process, each in its due proportion, as follows: Three hundred and fifty grams of coke, 40 grams of tar, and 400 grams of gas liquor, from which last is derived 6 grams of methyl alcohol, 6 grams of acetate of lime, and 4 grams of sulfate of ammonia. If this sample be multiplied a thousand fold to a metric ton, and the value of each product given at its present market price in Germany, the demonstration would be as follows:

Description	Value	
1 ton (1000 kilograms) of peat, costing, dried, 5 marks ($1.19), produces:	Marks	
350 kilograms (771.6 pounds) of peat coke.	15.75	$3.75
40 kilograms (88.2 pounds) of tar.........	2.20	.52
6 kilograms (13.2 pounds) of methyl alcohol	4.20	1
6 kilograms (13.2 pounds) of acetate of lime	.72	.17
4 kilograms (8.8 pounds) of sulfate of ammonia	.88	.21
Total	23.75	$5.65

The peat coke produced as the primary product of this process is jet black, resonant, firm, and columnar in structure, pure as charcoal from phosphorus or sulfur, and, having a thermal value of from 6776 to 7042 calories, it is so highly prized as a fuel for smelting foundry iron, copper refining, and other metallurgical purposes that it readily commands from 40 to 50 marks ($9.52 to $11.90) per ton. It is also a high class fuel for smelting iron ores, but, as the process is comparatively new and the output limited, it is as yet too scarce and expensive for blast furnace purposes. Crushed and graded to chestnut size, it forms an excellent substitute for anthracite in base-burning stoves. In larger lumps, as it comes from the oven, it fulfils substantially all the various uses of wood charcoal as a clean, smokeless fuel. The cost of a four oven plant, with all apparatus for cutting and drying the peat, distilling the gas liquor and extracting paraffin from the tar, is given at $95,200. Such a plant is reckoned capable of working up annually 15,000 tons of peat, the various products of which would sell, at present wholesale market prices, for 494,100 marks ($117,596). A plant of 12 ovens, with all appurtenances complete, would cost $261,800 in Germany, and should produce annually products worth $350,000, from which, deducting the carefully estimated cost of peat, labor, depreciation of property and other expenses—$179,200—there would remain a profit on the year's operation of $170,800. This process is in successful operation at Redkino, in Russia, and the German government has evinced its practical interest in the subject by placing at the disposal of the company a large tract of peat-moor lands, the property of the state, on which extensive works will be erected during the coming year.

The products that may be produced by such coking are many and valuable, and it is a question whether the by-products may not prove more valuable than the coke. A list of these include ammonia, ethyl alcohol, methyl alcohol, acetic acid, benzol, illuminating oils, paraffin, tar and heavy lubricating oils. With the exception of the ammonia, all these products can be used in the generation of gas if desirable, though ordinarily it would probably be more desirable to save each product.

Among the other uses for which peat has been employed may be mentioned the construction of pavements and the manufacture of paper and a substitute for terra cotta and papier-mâché, while carpets, celluloid and antiseptic bandages may be added to the list. It has also been employed to a slight extent in tanning. As a filtering agent peat charcoal is said to be superior to any other, and it is also said to be unsurpassed for use in the manufacture of powder for fireworks.

Agricultural value of peat

In the United States the way in which peat has been most extensively employed is in its character of swamp soil and as a fertilizer. The ordinary practice in using the swamp soil is to drain the swamp with ditches about 3 feet deep at suitable intervals, clear the surface of the woods and burn the stumps and loose cap of leaves or moss, after which the land is plowed. The application of a dressing of lime is beneficial in neutralizing the acidity of the peat. In this way a soil is prepared which is unexcelled for raising vegetables and nearly all crops except grain.

Many upland soils are improved[1] by the application of a dressing of peat or a compost of peat and stable manure, and the benefits derived come from two causes (1) its action in improving the texture and other physical qualities of the soil and (2) its direct fertilizing value.

The value of peat in improving the texture of the soil depends on (1) its powers of absorbing and retaining water; (2) its power of absorbing ammonia; (3) its effect in dissolving mineral matters; and (4) its effect on the temperature of the soil. Its value as direct fertilizer depends on some of the organic matter present, particularly ammonia and the small amount of potash, phosphoric acid and lime present. As these direct fertilizing ingredients rarely form 2% of the entire mass when free from water, it will readily be seen that the material as taken from the swamp need not be looked on as a source of supply for mineral fertilizers. In fact, where swamp soils give the best results, large amounts of commercial fertilizers are added, so that the value of peat as a direct fertilizer is almost nothing. The action of the organic acids present in peat is unknown; and it may be that some of these have a decided fertilizing effect, but the probability is that they have no fertilizing value, for ordinary crops can not be raised till these acids have been rendered insoluble.

The principal benefits arising from the application of peat to soils come from its mechanical effect, which makes light soils more retentive of moisture and ammonia and lightens clay soils.

Associated products

Marl. In many swamps, just beneath the peat, is a deposit of shell marl. This material, which is nearly pure carbonate of lime, is used extensively in the manufacture of Portland cement and lime. It is used instead of marble dust as a source of carbonic acid for use in charging soda water and other carbonated waters. Frequently the marl and peat are interstratified, in which case the marl usually predominates in the lower strata and the peat in the upper strata.

---

[1] Johnson, S. W. Essays on Peat, Muck and Commercial Manures.

Clay. The deposits of clay that underlie many swamps are of great value when accompanied by marl, with which it is mixed to make Portland cement.

Infusorial earth. In the open waters near the center of many bogs certain low grade plants and animals called diatoms and infusoriae respectively develop and add their remains to the bog accumulations. These plants and animals are composed largely of silica, and the remains form a deposit that is known by the various names of tripoli, infusorial earth and diatomaceous earth. Only two deposits of this material are known in this State, i. e., at White lake, Herkimer co., and Cold Spring Harbor, L. I., but careful prospecting will probably reveal other deposits in some of the large marshes. The principal purposes for which this material is employed are for heat insulation, metal polish and the manufacture of dynamite.

Bog iron ore. Another material that is likely to escape notice in ordinary prospecting is bog iron ore, which is found in many swamps just below the peat near the margin of the bog. The abundance of large supplies of better grades of iron ore prevent exploitation of these deposits, though many blast furnaces in Europe depend on this kind of ore for their supply. Many swamps in the Adirondacks contain large deposits of this material, and this seems to be the best locality in the State in which to look for this material, though it may be found in the swamps elsewhere.

PART 4

Distribution of swamps in New York State

With but few exceptions the large swamps are in those parts of the State that are approximately level. The salt marshes are found on the shores of Long Island, Staten Island, Manhattan Island and that part of Westchester county bordering on Long Island sound and the Harlem river, and the shores of the Hudson as far north as Newburg. A list of the marshes on Long Island and that part of Westchester county bordering on Long Island sound is given below, together with the approximate area of each marsh.

Salt marshes of New York State[1]

Lat. ° ′	Long. ° ′	Locality	Area in acres
41.04	71.55	Great pond, end of Long Island	285
41	72.03	Napeague harbor	332
41.01	72.08	Acabomack	316
41.08	72.15	Oyster pond	886
41.06	72.22	About Stirling and Greenport	127
41.05	72.21	Derring's harbor	16
41.03	72.20	West Neck harbor	32
41.04	72.19	Coecle's harbor	32
41.01	72.12	Three-mile harbor	127
41.02	72.13	Ely's brook	79
41	72.22	Jessup's neck	32
40.56	72.26	Jessup's neck, large swamp	569
41	72.27	Cutchogue harbor	253
41.02	72.25	Great Hog neck, east side; two thirds water	300
41.02	72.25	Great Hog neck, west side	32
41.03	72.28	Goldsmith's inlet	16
41	72.35	Mattituck pond	47
40.59	72.37	Luce landing	16
40.55	72.37	Flanders, Riverhead, Aquebogue	2182
40.57	72.51	Wading river	142
40.58	*.59	Mount Sinai harbor	285
40.55	*.50	Stony Brook harbor and East Flats	474
40.53	*.48	Nissequague river	211
40.54	*.45	West of Nissequague river	206
40.56	*.41	Crab meadow	316
40.56	*.37	Northport bay	111
40.53	*.35	Huntington harbor	32
40.56	*.31	Meadow, Lloyd's point	32

---

[1] Shaler, N. S. Eastern Sea Coast Swamps. U. S. Geol. Sur. 6th An. Rep't. 8:894–98.

*Long. east of New York city hall.

Lat. ° ′	Long. ° ′	Locality	Area in acres
40.52	*.30	Oyster Bay harbor	79
40.54	*.26	Mill Neck creek	300
40.54	*.24	Fox island to Lattingtown	221
40.54	*.22	Dosoris pond	79
40.52	*.22	Mosquito cove	150
40.52	*.18	Prospect point	63
40.48	*.21	Roslyn	32
40.48	*.18	Head of Manhasset bay	127
40.46	*.15	Little Neck bay	237
40.49	*.12	Throg's neck	127
40.52	*.12	Hutchinson river; incomplete	601
40.53	*.12	Along the coast, Rodman to Davenport's neck	474
40.54	*.13	New Rochelle	95
40.55	*.15	Delancey cove	316
40.56	*.17	Mamaroneck	221
40.57	*.19	Mill creek	316
40.58	*.20	Manursing island	190
41	*.21	Port Chester	47
41.01	*1.49	Three mile harbor	63
41	*1.45	North West creek	316
41	*1.42	Sag Harbor	63
41	*1.39	Noyack	95
40.56	*1.35	Cow neck and North Sea harbor	490
40.54	*1.30	Canoe Place	79
40.54	*1.26	Southport	300
40.52	*1.28	Tiana	111
40.50	*1.25	Shinnecock bay, shores of	696
40.50	*1.25	Quoque	
40.47	1.17	Around Moriches bay	
		Petunk	491
		Between Petunk and Forge river	554
		Front beach, etc.	949
40.37	*.25	Hempstead bay	4064

*Long. east of New York city hall.

Lat. ° ′	Long. ° ′	Locality	Area in acres
40.36	*.28	South Oyster bay islands	1787
40.39	*.30	Shore (long. .27′ to .35′) and Great island	3116
40.37	*.31	Islands	996
40.37	*.34	Jones beach and adjacent islands	1755
40.41	*.40	Coast inside (long. .35′ to .45′)	1866
40.38	*.40	Oak Island beach and adjacent islands	2704
40.43	*.45	Long. .45′ to Connetquot brook	1487
40.39	*.49	Fire Island	253
40.43	*.53	Connetquot brook to Edward's landing	712
40.44	*.56	Brown's point	206
40.44	*.59	Blue point and Mill's landing	158
40.45	*.59	Patchogue landing	79
40.45	*1.02	Swan creek to Howell's point	474
40.46	*1.06	Bellport bay	886
40.45	*1.09	Smith's point to end of chart of southern coast of Long Island, western part	712
40.45	73.50	Flushing bay	1978
40.49	73.50	Westchester creek	538
40.49	73.51	Just west of Westchester creek	316
40.49	73.52	Bronx river	380
40.48	73.55	Mott Haven and Port Morris	601
40.46	73.54	Near Berrians island	253
40.44	73.57	Hunter's point	1218
40.36	73.47	Rockaway beach	459
40.37	73.50	Islands in Jamaica bay	3732
40.37	73.50	Coast around Jamaica Bay	11070
40.35	74	Coney Island	949

The marshes on the Hudson and Harlem rivers are not listed, but there is almost no break in the mud flat of the Harlem river from Mott Haven to Spuyten Duyvil, though the area of this marsh is not known.

Lists of the swamps in southeastern New York were prepared by Mather and Beck; but after 60 years it is difficult to locate many of the swamps. There are many reasons for this. In the first place most of these deposits were shallow, and many of them have been drained, so that the only trace of the former swamp is a deposit of black soil that may not be a foot in thickness. As an example of this, the marsh south of Stissing pond, Dutchess co., which was reported to be underlain by about 2 yards of peat and to cover an area of 500 acres, is at the present day a fertile valley with a black soil about a foot thick in most places. In one place a deposit of peat about 11 feet thick still exists; and it is possible that Mather may have found just such a pit as was found by the author, and that it misled him into thinking that the entire flat was covered to the same depth.

---

* Long. east of New York city hall.

The Deuel swamp is another example of just such thinning out of a peat deposit. This swamp, which was reported by Professor Cassell to be about 150 acres in extent and underlain by about 6 feet of peat, is at present underlain by about 18 inches of black soil. I have no doubt that 60 years ago the deposit was 6 feet deep, but cattle have been pastured here, and their trampling has prevented the growth of the deposit and has caused the more rapid decomposition of the vegetable matter.

It would be difficult to find a spot in the entire State that is more than 10 miles from a swamp; and, though not all swamps furnish peat, yet it is within the limits of probability that peat will be found in at least half of them. The most extensive group of swamps is found in the Finger lake region and the lowlands near the St Lawrence river, though the largest swamp of all, the Drowned Lands of the Wallkill, is in the mountainous part of Orange county, which borders on New Jersey. Many peat deposits are found in the Adirondacks, and, as exploration is carried farther, the recorded number will be much greater. The depth of the Adirondack swamps is likely to be greater than that of most of the swamps in the central and western portions of the State, though the few visited by the author are not very deep.

I shall not attempt to give a list of the fresh-water swamps in the present work on account of the great number and the lack of accurate information in regard to underlying deposits, but would refer the reader to the topographic atlas sheets of the United States Geological Survey for maps of the swamps that have been surveyed. The lists prepared by Beck and Mather have been frequently quoted and will be found in their reports for 1842 and 1843, respectively. They are also quoted by Leavitt[1] and Ries,[2] and the latter has added an incomplete list of swamps in the Adirondacks and central and western New York.

PART 5

Description of important swamps in New York State

Drowned lands of the Wallkill. Along the Wallkill river is the great swamp, known as the Drowned Lands of the Wallkill, which extends from Sussex N. J. to New Hampton N. Y.

The bog varies in width from less than a mile at the state line to 4 or 5 miles near Little island or Durandville. Several islands, made up principally of gravel and undoubtedly of glacial origin, lie within this tract. The principal ones are Pine island, Black Walnut island, Big island and Little island, though other smaller ones occur in various parts.

The main portion of the swamp is on the east side of the Wallkill, though on the west side there is a swamp deposit that in some places is nearly a mile wide. The north end of the swamp and most of that portion on the west side of the river have been pastured, so that natural conditions no longer exist. An extensive tract extending from Orange Farm to a point about 2 miles north of Pine island has been drained and is used for truck gardening, but by far the greater part of the swamp is in its natural condition.

The name Drowned Lands may possibly give a mistaken impression of the nature of the swamp, as one might imagine that the surface is covered with water and would therefore be almost, if not quite, inaccessible. This however is not at present the case, inasmuch as very few places are covered with water, and over the greater part of this swamp a forest of both deciduous and coniferous trees is growing. At times of high water, however, the swamp is covered with water, and in February 1903, a large portion was covered with ice.

---

[1] Facts about Peat. p. 124.

[2] Uses of Peat and its Occurrence in New York State. 21st Rep't of the State Geologist.

On the forest floor is a dense carpet of mosses and liverworts, while tracts that have been burned over are covered with a dense copse of birch and poplar. In places where trees have been uprooted cat-tails and liverworts are the first plants to grow, but sphagnum moss and shrubbery soon take their part in restoring the original condition of affairs. The woodland between the river and Big island is made up principally of deciduous trees, though hemlock, pine and cedar grow here.

The woods near Pine island, on the other hand, are made up principally of cedars and tamaracks, and a moss of the genus Hypnum is the only one that forms any important part of the surface covering.

Near Black Walnut island the two types of vegetation seem to meet, and, as a result, the list of plants is larger, as most of the plants of the other sections are to be seen. In a tract of not more than 10 square rods the following ferns and mosses were found: *Osmunda cinnamomea*, *Dryopteris noveboracensis*, *Climacium* ———, *Dicranium undulatum*, *Strichum undulatum*, *Hypnum* ———, *Sphagnum* ———.

As would be expected from the topography of the region, the thickness of the peat varies from almost nothing to 18 feet or more. On the river bank at the north end of the swamp outcrops of peat are found which vary in thickness from less than a foot to 3 feet. This peat is dry and undoubtedly represents a deposit of wet peat several times the thickness of the dry material. Beneath this layer is a deposit of blue clay which sometimes contains leaf impressions. Sometimes a sandy marl intervenes between the peat and the clay. The surface rises gradually from the river bank, and a boring about 10 yards back showed peat to a depth of 5 feet. Where the marsh has been pastured, there is a black soil about a foot thick above the peat, and near the river this is sometimes made up quite largely of a sand or clay sediment. In the wooded portion the thickness of the peat increases very rapidly, and about a half mile from the river the clay was not reached till 17 feet of good peat was bored through. The thickness of the deposit at various points is as follows:

Pine island	18 feet	bottom not reached
Black Walnut island	18 feet	"
½ m. west of Durandville	16 feet	clay underneath
1½ m. west of Durandville	17 feet	"
½ m. west of Big island	12½ feet	bottom not reached
1 m. west of Big island	12½ feet	"
Florida	18 feet	"

A fair average of the depth would probably be about 18 feet, though many places are reported, on questionable authority, to have a depth of 50 feet. The quality of the peat from the surface to the underlying clay is apparently very uniform. Except near the river bank, no sand is to be detected, and the clay beneath it is very fine grained. A slight amount of sand is to be noticed in the clay in some places, though ordinarily it is remarkably free from grit. The small quantity of marl present is somewhat surprising, as about 2 inches of marly peat just above the clay are the only trace of its existence. From the fact that all classes of vegetation are present on the surface of the deposit, and that borings bring up nothing but pulpy peat and decomposed wood from all depths, it is readily seen that there has been no great change in the general type of vegetation in this place since the lake-filling process started. So far as the materials which form the peat are concerned, this deposit would hardly come under any of the classes of peat deposits given by Wagner, but would be rather a composite deposit.

Because of the great thickness and the jellylike consistency of the deposit, the quaking of this bog is more pronounced than in shallower deposits, which are underlain by marl. When a carriage passes trees near the roadside, the branches of trees may be seen to shake violently, and even the water in the drainage ditches rolls along in waves 1 or 2 inches high. The pulpy nature of the peat will be perceived when it is understood that a 2 inch auger may be pushed down to the clay, after the tough top layer is penetrated. The trunks of decayed trees seem to offer no resistance, being penetrated just as easily as the mass of peat formed from moss and leaves.

The soil on the drained portions is well adapted for nearly all crops except grain, though it is used almost entirely for raising garden truck. It is thought by some that it does not equal the soil of the Greycourt meadows, but this is very doubtful. It is quite likely, however, that lands which have been recently drained may not be so fertile as those which have been fertilized with lime and phosphate for some years, as the bog soil seems to be lacking in these elements.

The following table of analyses[1] shows the quality of the peat from the Drowned Lands.[2]

Test pit	Depth of sample	LOCALITY	Organic matter	Ash
1 A	1 ft down ..	West bank of river at highway bridge south of head of canal.	69	31
1 B	3 " ..		85	15
1 C	5 " ..		89	11
2 A	6 in. down..	1¾ m. n. 50° w. of Florida, about 300 feet from edge near house of Mr Powers.	49*a*	51
2 B	3 ft " ..		85*a*	15
3 A	14 in. " ..	At side of swamp road 1¼ miles n. 60° w. of Florida. About in center of that area of swamps.	78*a*	22
3 B	3½ ft " ..		87*a*	13
4 A	Surface soil	North side "Goshen turnpike," about ¾ mile southwest of Quaker creek, between Big and Black Walnut islands.	81	19
4 B	3½ ft down..		90	10
5 A	6 in. " .	North side of road, 150 feet west of Owen's Station, N. J.	90*a*	10
5 B	3½ ft " .		89*a*	11

---

[1] Analyzed by J. B. Gilmore, May 22, 1900.

[2] Freeman, John R. Report upon New York's Water Supply. N. Y. 1900. p. 520.

[a] Samples contain little or no iron.

The upturned roots of trees show how ill adapted the peat is for raising anything till it has been drained and the acidity neutralized. None of the trees show any taproots, and the tree derives its entire nourishment from the porous mass of moss and leaves on the surface. The roots are very wide spreading, so that a high wind is necessary to overturn a tree, but the roots have no hold on the subsoil.

Greycourt meadows. Between Chester station and Greycourt station are the Greycourt meadows, which embrace a tract of land estimated to be about 3000 acres. The entire marsh has been drained and is one of the most valuable tracts of farming or gardening land in the State. Near Chester, about 200 yards from the border of the flat, clay is found at a depth of 8 feet. Except for the top layer of soil, there is no perceptible difference in the character of the peat from the top to the bottom. The sample taken showed the same materials as the peat from the Drowned Lands.

Stissing pond. The formation of peat deposits by the filling of lakes is well shown on the margin of Stissing pond, near Pine Plains, Dutchess co.

At several points along the shore a fringe of bushes, about 50 yards wide, is growing, and outside of this a growth of cat-tails and rushes forms what at first might seem to be a cat-tail swamp with a slimy sediment over the bottom. A closer examination shows that under the bushes the surface of the marsh is covered with a growth of sphagnum moss and grass, which extends beyond the limits of the shrubbery and forms an intermediate stage between the cat-tails and the shrubs. Clinging to the cat-tails which lie beyond is another swamp moss, which forms a mat that will sustain the weight of a man. The last 10 feet of the cat-tails growth seems to have no moss, and beyond this are the rushes which are so common in lakes and ponds. The entire area that is covered with moss shows an abundant growth of ferns.

The general level of the growing vegetation is only slightly above the level of the water, though near the shore it is rising somewhat above it. This is undoubtedly due to the fact that the deposit has become a compact mass near the shore, but farther out the water beneath the vegetation permits the gradual subsidence of the mass as the new growth increases the thickness of the deposit. Though the weight of a man will be sustained, the moss sinks about a foot when any one walks on it, which may be taken as a proof that this mass is floating.

Borings about 100 yards from shore showed the growing vegetation and that which was not badly decomposed to be about a foot in depth. Some decomposed vegetation seemed to be clinging to the bottom of the mass, which is apparently floating, as the auger met no resistance for a space of a foot or two and then entered a slimy peat which extended to a depth of about 10 feet. The peat is somewhat gray from an admixture of marl, and at a depth of 10 feet a gray marl is encountered, the bottom of which was not reached.

Below Stissing and Thompson's ponds is an extensive flat which is probably the 500 acre plot referred to by Dr Mather. This extends to Attlebury and is underlain at points by peat. No great deposits were found (1902), though one small bog covering about an acre showed peat to the depth of 11 feet, with an underlying bed of dark blue clay.

The greater part of this flat is covered with a black soil, from 6 inches to a foot in depth, which is underlain by sand or clay.

Halcyon pond, formerly known as Buttermilk pond, has several marshy tracts along its shores, and a white streak of marl can be seen near the center of the pond.

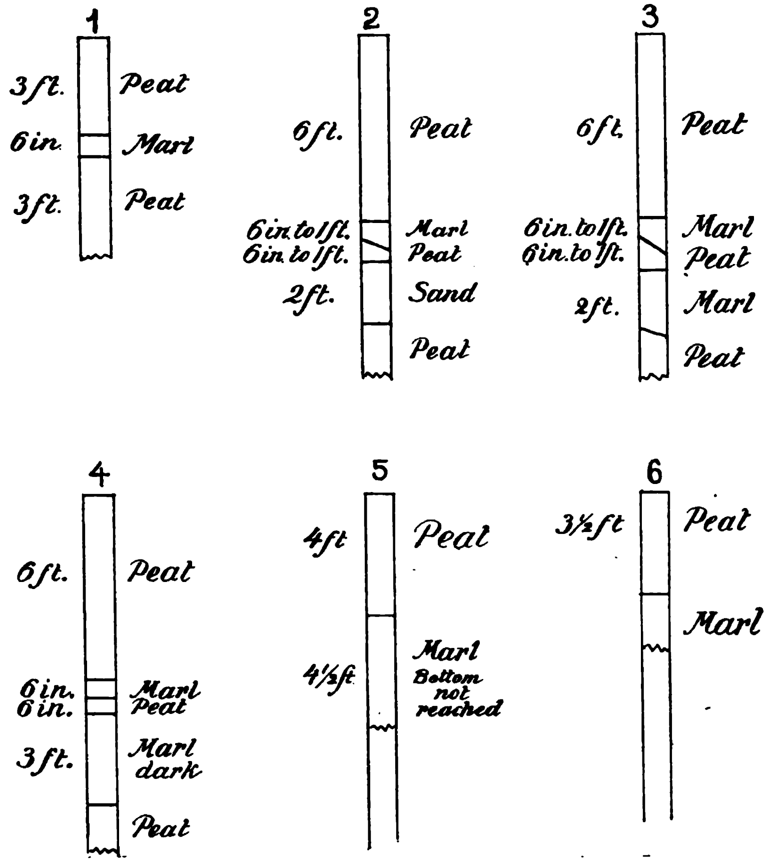
Deuel swamp. About 3 miles west of Amenia, Dutchess co., on the farm of A. W. Smith, is the Deuel swamp, which is the one mentioned by Professor Cassell as belonging to Lawrence A. Smith. About a foot and a half or two feet of black soil represents the deposit of about 6 feet mentioned in the old report. The swamp is used as a pasture and is covered by heath plants, grasses and some moss, though the amount of the last is small.

The pond just west of Amenia village shows several swampy areas, but they are small and have not reached the stage where bushes begin to grow.

Cicero swamp. The Cicero swamp, one of the best large deposits of peat in the State, is very easily studied. This swamp is about a mile and a half south of Oneida lake, and at its broadest part is about 2 miles wide, while its extreme length is about 25 miles. Three streams, the Canaseraga and Chittenango creeks, flowing into Oneida lake, and Mud creek flowing into Oswego river, pass through different parts of the swamp. The eastern part, sometimes known as the Cowaselon swamp, has been drained by the Douglas ditch, and the reclaimed land has been cleared and put into a high state of cultivation, but the soil is so light that rows of cedars and poplars must be planted as a wind-break to keep it from blowing away.

In the uncleared portions the original vegetation continues to flourish, and the dense forests of soft maple, elm and shrubbery still stand, growing on an accumulation of leaves and tree trunks which is rapidly being converted into peat. Though no sphagnum moss is to be seen in this portion of the swamp, hypnum and other mosses are abundant, and the growth of ferns, particularly the New York fern, is luxuriant.

Sections in various places show the top stratum of peat to be fairly uniform in depth; but the underlying strata are variable in thickness, as will be seen by a comparison of the following sections:



Sections of Cicero swamp at points between Oniontown and Ognon. Sections about 1 mile apart.

These sections were made in nearly a straight line from what is known locally as Oniontown, about 2 miles north of Canastota, through a place designated on the maps of the United States Geological Survey as Oniontown, but known locally as Ognon, to the road from Chittenango to Lakeport. In this article the local names are adopted. The sections were made at points a little more than a mile apart and represent a total distance of about 6 miles. The top stratum was found in all cases to be composed of spongy peat and a large percentage of partially decomposed wood which, in most cases, may be easily cut by a spade, though near the surface the decomposition is not sufficiently advanced to permit this. In the cultivated portions the surface is a black soil well adapted for all kinds of garden crops. The peaty character of the bog is not shown till a depth of a foot or two is reached, but thence downward to the marl or clay the peat is of apparently good quality. The top layer of peat ranges in depth from 3½ to 6 feet or more and is underlain in most of the swamp by a bed of marl. Two exceptions to this general rule were found north of Oniontown. In the first case clay was found at a depth of 3 feet near a creek in Oniontown, and in the second case, north of Oniontown, in a newly cleared portion of the swamp that has not been burned over to remove the leaves and other loose stuff not as yet changed to peat, the bottom of the peat was not reached at a depth of 6 feet.

The different strata of marl and peat are well shown along the Douglas ditch, and the thinning out of certain layers was well illustrated in one or two cases. As has been stated above, underneath the top stratum of peat is a layer of marl, the thickness of which varies from 6 inches to a foot. Immediately beneath this is another bed of peat which for several miles has about the same thickness as the marl above, but at the eastern part of the swamp the thickness of this bed increases, while near Ognon it gradually thins out and finally disappears. In the marl bed below the second peat deposit a gradual change in the mineral constituents is to be noted, as within the space of a half mile a total change from sand to marl was observed, though the thickness of the deposit continues about the same, and no change in color was to be observed. Whether the peat that underlies these deposits from the western part of the swamp to a point about a half a mile from Ognon, is to be found at Ognon is a question that is yet to be settled. It has been stated that the marl at this point is more than 50 feet deep, but thin beds of peat might easily be overlooked in such drilling as has been done here.

The presence of wood was noted only in the top layer of peat, but this of course does not prove that no wood is present in the lower layers.

In the western portion of the swamp, particularly that part in the town of Cicero, the surface conditions are entirely different from those of the drained portion north of Canastota. The thick growth of arbor vitae, tamarack, scrub pine and other shrubbery makes a typical "cedar swamp," which is almost impenetrable, and the network of roots and fallen branches makes excavation difficult. Near the southern edge, however, the swamp is covered with a forest of deciduous trees. Little, if any, moss is to be seen here, but all through the part where the cedars grow, is a luxuriant growth of sphagnum with some ferns and a liberal scattering of pitcher plants. Here as elsewhere the swamp has a springy, spongy feeling when one walks on it, but there is little if any danger from sink holes after reaching the mossy portion of the bog, though around the margin, where cattle have trampled the vegetation, the soil is a black, slimy mud which is almost impassable. The peat in this portion of the swamp is said to be from 6 to 8 feet in thickness and is underlain by marl. In many places the moss has been stripped by nurserymen for use in packing trees and shrubbery.

Pleasant lake. A small unnamed swamp in the town of Schroeppel, Oswego county, about a half mile northwest of Pleasant lake is a typical example of lake filling. In the center of the marsh is a small pond, the remnant of a fair-sized lake, which is entirely surrounded with an accumulation of peat of unknown depth. A great portion of this bog has recently been stripped of its moss, and consequently the new growth of moss does not furnish such a firm foothold in crossing as does the older and thicker growth of several years. The bog is very spongy and is rapidly filling in the pond at the center, which at present is but a few rods across. The mass underlying the new growth is not so much decomposed as might be expected and would possibly furnish a good fiber for paper. The bottom layers are well decomposed and when dried would make excellent fuel.

The color of the growing moss and pitcher plants in this bog was quite remarkable. In the clumps around trees where the moss has not been stripped, the color of the moss was almost uniformly green, and the pitcher plants were green with the well marked purple stripes so common to them, while in the portions that had been stripped the new growth, both of moss and pitcher plants, was almost uniformly a brilliant reddish purple. This at first sight might seem to be due to a difference in the organic acids furnished as fertilizing ingredients, but the existence of both purple and red moss in the same clump and under identical conditions in the swamp near Owl's Head seems to oppose this theory.

Phoenix. About 2 miles east of Phoenix in the same town of Schroeppel is a large marsh which comes down to the bank of the Oneida river and borders it for about a half mile. Two small creeks pass through this marsh, and along their shores was the only place where observation could be made this year (1902). A growth of elms, maples and other deciduous trees seems to cover the entire swamp. Hardly any conifers are to be seen, and the trees range in size from a foot to 2 feet in diameter. On the occasion of the author's visit, the surface was covered with silt and water and was so soft that only in a few places would it bear the weight of a man. Some portions which have been cleared and drained make good farming land, and it is said that peat underlies a large portion of the swamp. At only one place, however, was any indication of its existence seen by the author, and that was where a telephone pole had been set in the marsh, and a few pieces were brought up in digging the hole. No information in regard to the depth of the peat or the thickness of the overburden was to be obtained, but there is no question as to its existence at this point.

Owl's Head. About a half mile south of Owl's Head station, Franklin co., is a large marsh of apparently very recent origin, which may have been formed within the past 50 years. Around its borders is a dense growth of arbor vitae and tamaracks, a typical "cedar swamp," but with very little peat underlying it.

In the central portion of the marsh, however, no living trees are to be seen, but here and there are the bare trunks of cedars amid the luxuriant growth of sphagnum moss and cranberry bushes. The sphagnum is both red and green, but the different species were not determined. The trunks of fallen trees in many places are indicated by streaks of gray lichens, while underneath circular clumps of the same lichens are found glacial boulders. The depth of the bog is a matter of surprise when the large area is considered. In no place is the entire accumulation of moss and peat more than 4 feet deep, and in many places the shallowness of the deposit is evinced by the glacial boulders which show above the surface. A somewhat remarkable circumstance is the apparent avoidance of these boulders by the sphagnum moss, for almost invariably, the boulder is surrounded by a pool of black water in which the sphagnum does not grow as luxuriantly as in the remainder of the swamp. The peat is of apparently good quality and is underlain by a bed of fine sand, which is well cemented, so as to be almost a sandstone, though it breaks up readily in exposed places. The character of this sand is shown in the ditches at the side of the railroad, where a small waterfall has been formed by the wearing away of the uncemented sand beneath the harder layer immediately underlying the peat. The existence of sand underneath bogs seems to be characteristic of the Adirondack and northern New York swamps, as many of the cedar swamps have such material beneath the peat, instead of the clay that is so much more common in the marshy deposits of the central part of the State.

Madrid and Knapp station. About 2 miles west of Madrid, St Lawrence co., on the Ogdensburg & Lake Champlain Railroad, is a bog extending along the railroad for about a mile and a half on each side. On the south side of the railroad it is said to be about a mile wide, while on the north side it extends for several miles. Much of the surface is covered with arbor vitae, and very little if any sphagnum moss is to be found; none was noticed by the author. Parts of the swamp have been cleared, and on the north side of the railroad the cleared portions become good farming land, but, on the south side, nothing but a coarse marsh grass takes the place of the woods. At a depth of 4 feet the bottom of the peat is not reached, and apparently the quality is good. Decomposed wood is one of the important constituents in this peat, as is the case in most of the peat deposits in New York State.

Near Knapp station, a few miles east of this marsh, is another "cedar swamp," but, though many excavations were made, there was only one case where the material found might be called peat. The depth of the organic matter was not more than 2 feet and consisted of a brown or black muck underlain by sand. In one place a few clumps of sphagnum about 3 feet across were seen, which are probably the remnants of a once luxuriant growth of this plant.

Though the bottom of the peat deposit at Madrid was not reached, it is probable that, like the swamp at Knapp station it is only a shallow deposit, as the country is comparatively level, and the rocks are in many cases well exposed near the streams.

Montezuma marshes. North of Cayuga lake is a great tract of swampy land, which has been covered with water for the greater part of many years, and is known as the Montezuma marshes. The extreme length from the foot of Cayuga lake to Howland island is about 15 miles, and its greatest breadth is about 3 or 4 miles.

In many ways this is one of the most peculiar swamps in the State, for, though it is at the foot of the lake, it is essentially a delta swamp. After the subsidence of Lake Iroquois, when the waters of Cayuga lake covered the entire area now occupied by the marsh, the Clyde and Seneca rivers flowed directly into Cayuga lake. Gradually the sediment brought by these streams made the water shallower, so that the aquatic plants sprang up, and these in turn have in many places been replaced by marsh grasses. The filling process has not depended entirely on these streams for its supplies, for under a great part of the swamp, a thick deposit of shell marl of remarkable purity is found, and this must have been formed in comparatively pure water.

At present the Clyde river flows through the swamp parallel to the Erie canal into the Seneca river. The greater part of its sediment is deposited near its banks, forming a dike, which retains the water that flows over the swamp at high water. The Seneca river flows into the lake at its foot, after passing through about a mile or two of the swamp, and with scarcely a turn becomes the outlet of the lake and receives the waters of the Clyde river about 5 miles north of the lake. The amount of sediment carried by these rivers is comparatively small, as they receive the greater part of their waters from Canandaigua, Keuka and Seneca lakes.

Near the borders of the swamp are dense forests of maple, elm, etc., but in the main body of the swamp no shrub larger than an elderberry bush is to be seen, while the mass of the vegetation consists of cat-tails, sweet flags and marsh grasses, which are a source of no little revenue to the people in the neighborhood, who cut the cat-tails and flags for use in tight cooperage and rush bottom chairs and sell the marsh grass for packing material.

The entire absence of mosses in those portions of the swamp visited by the author is a matter of surprise and is a distinct characteristic of this swamp. It may be, however, that some of the woods near the margin have a growth of moss.

Near the margin of the swamp and close to the banks of the creeks and rivers flowing through it, the top soil is merely a black muck with a great deal of silt intermixed, but near the site of the Duryea Portland Cement Works, which were destroyed by fire some years ago, peat of apparently good quality is found. The depth of the deposit is about 6 feet, and immediately beneath it is a bed of marl about 14 feet thick, which is underlain by clay.

This peat is nearly black and very fibrous, being composed almost entirely of cat-tails and grasses. With the exception of the top layer of undecomposed material, very little difference is to be noticed between this material and other well decomposed peat.

At the foot of Cayuga lake, near the shores of the Seneca river, the accumulation of vegetable matter is mixed with a great amount of silt and is only about 18 inches thick. It is underlain with a clear white sand somewhat intermixed with plant stems.

In view of the fact that at high water the entire marsh is flooded, the small amount of sediment and the comparative purity of the peat are a matter of surprise, but it must be remembered that Cayuga lake acts as a great settling basin, so that little sediment reaches the swamp except from the Clyde and Seneca rivers.

The extent of the peat is unknown, but tests and borings for the location of marl deposits indicate that it is to be found over the greater portion of the marsh.

In the midst of the swamp are several islands, composed principally of glacial debris, which are covered for the most part with a fine sand. The villages of Fox Ridge and Savannah are located on two of these.

In a shallow depression on the top of the high ridge of land south of Savannah, is a small "cedar swamp" which contains peat of apparently good quality. The bottom was not reached on account of the lack of proper tools, so that the character of the subsoil is not known, but the probability is that it is a fine grained sand, possibly a molding sand. This swamp is quite firm and does not have, when one walks on it, the springy, spongy feeling that is so marked in the Cicero swamp and many of the other large swamps. Except for the presence of tamaracks and other moisture-loving trees, there is nothing at this point to indicate the presence of peat, and the presence of this deposit seems to be almost inexplicable; for, even in the wet season of the summer of 1902, the surface was apparently dry, and water did not come into the test holes rapidly enough to interfere with the digging. At a depth of 3½ feet the peat showed an excellent quality for fuel, but no trace of sphagnum moss was to be seen either on the surface or in the partially decomposed peat. The origin of this swamp is undoubtedly the same as that of the swamp in the kettle on the Pinnacles in Rochester and owes its existence entirely to rain water and moisture from the air.

Pinnacle marsh, Rochester. An interesting peat bog[1] is found in a depression or kettle in the Pinnacle hills within the limits of the city of Rochester. Its total area is only about 1 acre, and the surface is covered with a growth of yellow birch and herbaceous plants. The depth of this bog is 25 feet, and the peat is of good quality. Several sticks of wood were found, which could be cut like soft cheese, but, when seen by the writer some seven years after they were dug, they were very hard, though badly cracked. One of these from a depth of 10 feet has been identified as the red maple (*Acer rubrum*).

Three analyses of material from various depths by Mr Edward Hirschfield give the following results.

			Moisture	Ash
A	from	surface	14.47	2.15
B	"	a lower depth	14.23	3.05
C	"	still deeper	14.51	5.08

This would give for organic matter, A 83.38%, B 82.72% and C 80.41%.

Oak Orchard swamp. The Oak Orchard swamp in Genesee and Orleans counties is divided into three distinct sections, which are covered for the greater part with forest growth and are underlain in most portions by peat. The eastern section is by far the largest of the three, and the depth of peat is greater, but the borings did not show the full depth of the peat. In this portion I did not notice mosses, but am inclined to think it is because careful search was not made. About the center of this section is a large, open tract of grass land underlain by peat of the same character as is to be found in the woods. Several islands of glacial origin are located in this swamp, and some of the best gravel for road building is obtained on them.

---

[1] Fairchild, H. L. & Barnum, E. G. The Pinnacle Peat Marsh. Rochester Acad. Sci. Proc. March 1900. v. 3.

The section north of Oakfield is covered with a dense growth of white cedar, and the surface is carpeted with sphagnum and Marchantia. The peat is 3 feet deep, though the last foot is intermingled with marl and calcareous tufa. The subsoil is clay.

North of Alabama the deposit can hardly be dignified with the name of peat, for it is drier than in the other portions and has a sandy subsoil, and the peat contains a large percentage of foreign matter. The forest growth is principally made up of white cedar, though many deciduous trees are found. Sphagnum is not common, but is replaced by a moss of the genus Hypnum.

The eastern section of the swamp would probably furnish a good supply of peat for fuel, but the greatest profit will undoubtedly come from its use in agriculture. The other portions will make excellent soil, but will furnish no peat of any account for fuel.

Byron. About 2 miles northeast of the village of Byron is a swamp about 4 miles long and a mile or a mile and a half wide. It is known as a cedar swamp and is covered with a dense growth of arbor vitae and some pine, hemlock and tamaracks. Ferns are abundant and Hypnum, Sphagnum and Marchantia form a dense carpet, beneath which is a deposit of peat and marl.

For about 3 feet the peat is of good quality, but at that point a crust of calcareous tufa is encountered. Beneath this calcareous tufa no good borings could be made, but the greater part of the material to the depth of 9 feet was marl, though the auger did not bring up much, because the water washed off the greater part, and particles of peat became intermixed in withdrawing the auger. At a depth of about 9 feet good peat is again found, and at 11 feet the bottom was not yet reached.

In this swamp there is a decided odor of sulfureted hydrogen at the point where the calcareous tufa is found, which is probably due to a decomposition of gypsum in solution.

Caledonia. About a mile east of the village of Caledonia is a large cedar swamp which contains some peat, though the quantity is not great. The value of this swamp lies in the extensive deposit of marl which is found here and is used in the manufacture of Portland cement by the Iroquois Portland Cement Co. The surface vegetation could not be ascertained on the occasion of the author's visit, on account of snow, but the top layer of vegetable matter is hardly worthy of the name of peat, as it consists of about a foot or a foot and a half of light partially decomposed vegetation. Beneath this layer is a lenticular stratum of marl, which is underlain by a deposit of peat or lignite about a foot thick. The upper marl deposit has a maximum thickness of about 6 feet and thins out to nothing, so that the two layers of vegetable matter come together and form one deposit. The lower stratum of vegetable matter consists of the trunks of trees intermingled with compact peat, and underneath it is another deposit of marl, which is continuous to a depth of 14 feet from the surface of the swamp. The alternations of peat and marl in this case can hardly be explained except on the supposition that the floating bog on the surface of the lake which once covered this space, sank in the manner described in a former chapter.

Several deer antlers have been found at this place, but it is unknown whether they came from the upper or lower bed of vegetable matter, as they were found in the cement factory when the marl was being put into the drier.

PART 6

Bibliography

Alloway, R. M. Utilization of Peat. Jour. Soc. Arts. 19:30.

Ansted, D. T. Circle of the Sciences; article on geology. Lond. and N. Y. 1862 etc.

Bach, A. Peat Fuel. Inst. Civ. Eng. Proc. 1900–1. v. 147.

———. Art. on Peat. Min. Ind. 7:191.

Bailey, A. Peat Floods in the Falklands. Nature, 34:440.

———. History and Uses of Peat. Am. Jour. Sci. 15:250.

———. Manufacture of Peat. Dub. Univ. Mag. 82:384.

Baskerville, C. Am. Chem. Soc. Jour. 21:706.

Björling, P. R. Colliery Guardian. 80:1127, 1183, 1294; 81:21.

Blavier. Considerations sur le charbonage de la tourbe, l'histoire de cet art. Ses procédés et son utilité. Jour. des Mines. 1794 or 1795. 1 (pt 2), 19 et seq.

Brande. On Peat and Its Products. Roy. Soc. Proc. Jan. 31, 1851; also Am. Jour. Sci. Ser. 2. 11:440.

Byrne ——. On Compressed Peat.

Carter, W. E. H. Peat Fuel: its Manufacture and Use. Ontario Bur. Mines. Bul. 5. Toronto 1903.

Chevalier. Sur la carbonisation de la tourbe à Crouy-sur-Ourcq. Annales des Mines. Ser. 2. 1829. v. 223.

Cleaveland, Parker. Elementary Treatise on Mineralogy and Geology. Bost. 1822.

Cole, G. A. J. Bog-slide in Knocknageeha. Nature. 55:254.

Cook, G. H. Geol. N. J. 1868. p. 481.

Dal, Adolf. Utilizing the Peat Fuels of Europe. Eng. Mag. Nov. 1902. 24:2.

Dana, J. D. Manual of Geology.

Dana, S. L. Muck Manual. Lowell. 1842.

Ells, R. W. Peat. Geol. Sur. Can. An. Rep't. 1888-89. p. 85K.

———. Peat Industry of Canada. Ontario Bur. Mines. 2d rep't. 1892. p. 195.

Fairchild, H. L. & Barnum, E. G. The Pinnacle Peat Marsh. Rochester Acad. Sci. Proc. Mar. 1900. v. 3.

Fruh ——. Ueber Torf und Dopplerit. Zurich 1883.

Gowenlock, N. Peat and its Uses. The Cultivator and Country Gentleman. 1875. p. 275.

Hitchcock, C. H. Reports on Geology of Massachusetts. 1835, 1841, and 1856.

———. Geology of New Hampshire.

Hitchcock, E. Geol. Vt. 1861. 1:174.

Holland, John. History and Description of Fossil Fuel. Lond. 1841.

———. Geology of New Hampshire. v. 3.

Hull, E. Geol. Sur. Ireland.

Hunt, T. S. Peat and its Applications. Geol. Sur. Can. Rep't of Progress. 1866.

Jackson, C. T. Report on the Geological and Agricultural Survey of Rhode Island. 1840.

———. Geology and Mineralogy of New Hampshire. 1844.

Johnson, S. W. Essays on Peat, Muck and Commercial Manures. Hartford 1859.

———. Peat and its Uses. N. Y. 1866.

Julien, A. A. On the Geological Action of Humus Acids. Am. Ass'n Adv. Sci. Proc. 1880. 28:311-410.

Kane, Robert. The Industrial Resources of Ireland. Dublin 1844.

Keller, Theo. Die Torfindustrie. Abs. 2, p. g. 24. Hartleben, Wien. 1899.

Kinahan, G. H. Peat Bogs. Jour. Sci. 11:294.

Leavitt, T. H. Facts about Peat. Bost. 1867.

Lesquereaux, L. Origin of Coal. Pa. Geol. Sur. An. Rep't. 1885. p. 109; *also* Hayden's survey. 1872 (Sphagnum as a Peat-maker).

Lyell, C. Principles of Geology. 2:502.

MacCulloch, J. Origin and Formation of Peat. Edin. Philos. Jour. 2:40, 201.

Moore, J. S. On the Growth of Turf Bogs of Fibrous Character. Jour. Roy. Geol. Soc. Dub. v. 12.

Müller, G. Die Verbreitung der Deutschen Torfmoore nach statistischen Gesichtspunkten dargestellt. 2 p. G. 1899. p. 277, 314.

Newberry, J. S. Geol. Sur. O. Rep't of Progress, 1869. Columbus 1871.

———. Geol. Sur. O. 2:122-4.

Newton, W. E. Employment of Peat in the Useful Arts. Jour. Soc. Arts. 8:433.

Orton, E. Peat Bed beneath Drift in Ohio. Am. Jour. Sci. 100:54.

Page, W. H. Making Coal of Bog Peat. Iron Age, Aug. 18, 1898. 62:3.

Patin, Charles. Traité des tourbes combustibles. Paris 1663.

M. Pelouze, *pére.* Traité méthodique de la fabrication du coke et du charbon de tourbe. Paris 1842.

Percy, John. Metallurgy: Refractory Materials, and Fuel. Lond. 1875.

Rennie, R. On Peat.

Ries, Heinrich. Peat. U. S. Geol. Sur. Mineral Resources of U. S., 1901. Wash. 1902.

———. Uses of Peat and its Occurrence in New York State. N. Y. State Geol. 21st An. Rep't. Alb. 1900.

Roth, J. Alg. Chem. and Phys. Geol. 2:639.

Rowlee, W. W. Swamps of Oswego County, N. Y. and their Flora. Am. Nat. v. 31.

Schöndeling. On Manufacture of Peat Fuel. Glückauf. 36:793-97. Abstract Jour. Iron and Steel Inst. 1900. 2:487.

Schroder, F. H. Zur Torfbereitungsfrage. Dingler's Polytechnisches Journal. 1860. 156:128-40.

Senft, F. Humus, Marsen, Torf, und Limonit-Bildungen. Leipzig 1862.

Seyfert, A. G. Peat in Canada. Eng. and Min. Jour. Sep. 23, 1899. p. 371.

Shaler, N. S. Fresh-water Morasses of the United States, with description of Dismal Swamp district of Va. and N. C. U. S. Geol. Sur. 10th An. Rep't. pt 1, p. 255-339.

———. On Peat and Swamp Soils. United States Geol. Sur. 12th An. Rep't. p. 311.

———. Preliminary Report on Sea Coast Swamps of the Eastern United States. U. S. Geol. Sur. 6th An. Rep't.

———. Fluviatile Swamps of New England. Am. Jour. Sci. Ser. 3. 33:210-21.

———. Swamps of the United States. Science. 7:232.

———. Origin, Distribution and Commercial Value of Peat Deposits. U. S. Geol. Sur. 16th An. Rep't. pt 4, p. 305-14.

Sherzer, W. H. Mich. Geol. Sur. 7:10, 24, 156, 157, pt 1, Geol. of Monroe County.

Stern, L. Peat Fuel. Am. Architect & Building News. v. 45.

———. Peat in Germany. Cassier's Mag. 10:111.

Taylor, Richard C. Statistics of Coal. Phil. 1848.

Vogel, August. Der Torf, seine Natur und Bedeutung. Braunschweig 1859.

Websky, Justus. Beiträge zur Erkentniss der Zusammensetzung und Bildung des Torfes. Erdmann's Journal für praktische Chemie. 1864. p. 65-96.

Wheeler, W. H. Commercial Uses of Peat. Nature, 63:590.

White. Geol. Ia. 1870. 2:275–88.

Winchell, N. H. Glacial Lakes of Minnesota. Geol. Soc. Am. Bul. 12:109.

Wragge, R. Utilization of Peat. Jour. Soc. Arts. 19:201.

Zirkel. Petrographie. 1894. 3:626.

Peat, Its Use and Value for Fuel. Ont. Bur. Mines. 1st rep't. 1891. p. 175.

Moss Litter and the Special Advantage of Sphagnum. Ont. Bur. Mines. 1896. p. 185–92.

Ont. Bur. Mines. 1900. p. 21.

Mineral Industry. 2:489; 7, 191.

Wis. State Agric. Soc. Trans. 1874–75. p. 75–92; Geol. Wis. 2:240–46.

Utilization of Belgian Peat. Note in Eng. and Min. Jour. Oct. 4, 1899.

Geol. O. 1:221, 509, 571; 2:222; 3:454, 499.

NOTES ON THE GYPSUM INDUSTRY IN NEW YORK

BY

ARTHUR L. PARSONS

CONTENTS

PAGE
Introduction 91
History 114
Uses 117
  Portland cement 125
Processes of manufacture 126
Technology of gypsum 130
  New York mines and mills 137
  Production of gypsum in New York 148
Analysis of gypsum 148
List of firms and individuals that mine and manufacture New York gypsum 155
List of manufacturers in New York State who use gypsum from outside of this State 156
Bibliography 156

NOTES ON THE GYPSUM INDUSTRY OF NEW YORK

Introduction

In presenting this sketch of the gypsum industry of New York State, the writer desires to say that the greater part of the history, geology and technology is a compilation of information already published.

The description of the New York State mines and mills is based on field work performed by him. At this time, he wishes to thank the producers of gypsum for the facilities for study which were placed at his disposal and the uniform courtesy which has been extended to him. In particular he desires to thank Mr F. M. Severance, who has furnished much historical data in regard to the Fayetteville deposits.

The publications which have been most largely drawn on are Grimsley's *Special Report on Kansas Gypsum,* Knapp's *Chemical Technology,* Wagner's *Chemical Technology* and New York State Museum bulletin 11.

Gypsum. Gypsum, the hydrous sulfate of lime, has the chemical formula $CaSO_4 + 2H_2O$ and, when pure, contains 32.5% of lime (CaO) 46.6% of sulfur trioxid (SO_3) and 20.9% of water (H_2O). It occurs both in isolated crystals and in large masses of apparently amorphous rock, though even the most compact varieties show cleavage planes and crystal faces under the microscope. It is one of the softest minerals, and is easily scratched with the thumb nail or cut with a knife. In the Mohs scale of hardness it is given as 2, graphite being 1 and diamond 10.

Gypsum crystallizes in the monoclinic system, the crystals being usually tabular or prismatic with pyramidal terminations. Twin crystals are very common. It has a perfect cleavage and from the moonlike luster of the cleavage surfaces is derived the name selenite (Greek σελήνη) which is applied to the clear crystals and platelike cleavages.

When heated moderately in a closed tube, the water of crystallization is given off and the fragments of plaster, when water is added, have the power of recombining with the water in such a way as to form the original compound. If heated to a temperature of 343°C., however, gypsum is converted into anhydrite ($CaSO_4$) which will not harden or set with water.

The principal varieties of gypsum are,

1 Selenite, in transparent plates or crystals

2 Fibrous gypsum or satin spar

3 Alabaster, a compact white gypsum used extensively for ornaments

4 Rock gypsum, a dull variety containing more or less impurities

5 Earthy gypsum, or plaster earth.

When pulverized, all these forms become a white or gray powder. Its specific gravity varies from 2.314 to 2.328. It is sparingly soluble in water, as shown by the following table by Marignac.[1]

Temperature	One part of gypsum dissolves in	
0°C	415	parts of water
18°C	386	"
24°C	378	"
32°C	371	"
38°C	368	"
41°C	370	"
53°C	375	"
72°C	391	"
86°C	417	"
100°C	452	"

It occurs very abundantly both in a solid state and in solution. As plaster rock, it occurs in large masses and is usually found associated with salt, clay and shale. In the manufacture of salt, a certain percentage of gypsum is always present in the brine and must be removed. Sometimes the crystals of selenite obtained from the brines rival in perfection the best that are found in nature.

---

[1] Annales de Chimie, Paris. Ser. 5. 1:274–81. Quoted by Grimsley, Special Report on Kansas Gypsum.

It is present as a constituent of all sea water in quantities which vary in accordance with the quantities of the other mineral constituents. The following analyses show the constituents of sea water from different seas.[1]

	Caspian sea	Black sea	Baltic sea	North sea	Mediterranean sea	Atlantic ocean	Dead sea
Salts in solution..........	.63	1.77	1.77	3.31	3.37	3.63	22.3
Water....................	99.37	98.23	98.23	96.69	96.63	96.37	77.7
The solid matter contains:							
NaCl.................	58.25	79.39	84.7	78.04	77.03	77.07	36.55
KCl	1.27	1.07	......	2.09	2.48	3.89	4.57
$CaCl_2$..............	......	......	......	.2	....	....	11.38
$MgCl_2$..............	10	7.38	9.73	8.81	8.76	7.86	45.2
NaBr & MgBr........	......	.03	......	.28	.49	1.3	.85
$CaSO_4$..............	7.78	.6	.13	3.82	2.76	4.63	.45
$MgSO_4$..............	19.68	8.32	4.96	6.58	8.34	5.29	
$CaCO_3$ & $MgCO_3$	3.02	3.21	.48	.18	.1		
Nitrogenous and bituminous matter	......	......	......	......	....	....	1

Several theories have been advanced to explain the formation of gypsum deposits, the principal of which are (1) Credner's theory of deposition from sea water, (2) deposition from thermal springs, (3) formation by volcanic agencies, (4) formation by the action of sulfids on limestone, (5) solution and deposition by spring waters, resulting in secondary deposits.

The following statement of H. Credner's[2] theory of the formation of salt and gypsum beds is in the main from a translation by Dr F. J. H. Merrill, appearing in bulletin 11, New York State Museum, entitled *Salt and Gypsum Industries of New York.*

---

[1] Wagner. Chemische Technologie. 11th Auflage, p. 227. Quoted by Merrill. N. Y. State Mus. Bul. 11, p. 8.

[2] Elemente der Geologie. 6th Aufl. Leipzig 1887. p. 317-20.

(1) *Credner's theory.* The beds of rock salt and gypsum which occur in the earth's crust have been produced by direct separation from sea water or from the water of inland seas in which chlorid of sodium was the principal substance held in solution. In quiet bodies of salt water, the stronger brine formed at the surface by evaporation sinks to the bottom and accumulates there, so that a concentration of the salt takes place from the surface toward the bottom. In open seas full of currents, such a concentration can not occur, for, on the one hand, in consequence of the currents, there is a constant mingling of the stronger and weaker solutions of salt, and, on the other, the rivers replace the evaporated water, but in inland seas, specially those into which but little river water flows, the saturated solution of salt sinks to the bottom, from which rock salt crystallizes out and by continual accumulation, a layer of salt is formed. In periods of excessive rainfall, when the tributary streams are muddy, beds of saliferous clay are deposited, while, on the other hand, in periods of drouth, when no mud is borne by the streams and more water is evaporated than is contributed by the streams, deposits of pure rock salt are formed. If the water of a bay in which such process of evaporation and deposition is going on, contains sulfate of lime, a deposit of gypsum is formed before the separation of the salt begins, because the water becomes saturated with gypsum sooner than with salt. In consequence, beds of rock salt are frequently found overlying beds of gypsum and anhydrite. With a new influx of sea water, the water of the bay becomes less saturated with the saline materials, and the deposition is interrupted, and, in case this interruption occurs before the salt has been deposited, we may have a layer of gypsum overlain by layers of saliferous clay, or in some cases, limestone.

By the drying up of an inland sea originally containing salts in solution, the first substance to separate from the water would be gypsum, then layers of rock salt containing some impurities, after which pure rock salt would be deposited, and on top would be found a layer of the more easily soluble sulfates and chlorids.

In such a case, however, the deposit would be of a comparatively small thickness, since it would contain only the materials which were dissolved in the waters of the inland seas. The great deposits of gypsum and rock salt have undoubtedly been formed in some bay where there has been a continuous or intermittent influx of water containing gypsum and salt. An instructive example of such a deposit and chemically the most complete one in the world, is that of Stassfurt, Germany.

Its lower principal mass consists of rock salt, which is divided by thin parallel layers of anhydrite into beds from 2 to 5 inches in thickness. Upon it rests a stratum, 200 feet thick, of impure rock salt mingled with easily soluble compounds such as chlorid of magnesium, which is divided by thin layers of polyhalite.[1] Upon this is a stratum 180 feet thick, in which rock salt and sulfates, principally kieserite[2] (sulfate of magnesia), occur in alternate layers, some of which are a foot thick. The uppermost bed, about 135 feet thick, is composed of a succession of reddish layers of rock salt and salts of magnesium and potassium (kainite,[3] kieserite, carnallite[4] and tachhydrite[5]) in addition to which are also masses of snow-white boracite.[6] The boundaries between these four principal divisions are not exact, and the change from one to the other is gradual.

(2) *Thermal springs.* In regions where geysers and thermal springs are abundant, in some cases the water contains sulfurous acid, which becoming oxidized, changes to sulfuric acid, and this acting on the carbonates, changes them to sulfates. In this way dolomite may be changed so as to form gypsum and epsomite.

(3) *Volcanic agencies.* Near some of the volcanos, particularly at Girgenti, in Sicily, gypsum, aragonite, sulfur and celes-

---

[1] Polyhalite, $2\ Ca\ SO_4,\ Mg\ SO_4,\ K_2\ SO_4 + 2\ H_2\ O$.

[2] Kieserite, $Mg\ SO_4 + H_2\ O$.

[3] Kainite, $Mg\ SO_4,\ K\ Cl + 3\ H_2\ O$.

[4] Carnallite, $K\ Cl,\ Mg\ Cl_2 + 6\ H_2\ O$.

[5] Tachhydrite, $Ca\ Cl_2,\ 2\ Mg\ Cl_2 + 12\ H_2\ O$.

[6] Boracite, $2\ Mg_3\ B_8\ O_{15},\ Mg\ Cl_2$.

tite are found intimately associated with one another. Whether these minerals are formed directly by volcanic action or are secondary minerals, can not in all cases be definitely stated. It is however observed in many specimens that the aragonite and sulfur crystals are inclosed in clear plates of selenite. This fact goes to show that gypsum was formed later than the other minerals, and its formation was possibly due to the action of sulfuric acid, either as a volcanic gas or in solution, as is the case in thermal springs, on crystals of calcite or beds of limestone, though the probability is that the selenite was deposited from water containing gypsum in solution.

(4) *Formation through the action of pyrite on limestone.* The sulfid of iron in the form of pyrite and marcasite is found in many clays, and, when oxidized, forms iron sulfate, which, when brought in contact with the carbonate of lime, brings about a double decomposition, changing the sulfate of iron into siderite (or iron protocarbonate) and the carbonate of lime into sulfate of lime (or gypsum).

(5) *Solution and deposition by spring waters.* In regions where beds of rock gypsum occur within range of ground water circulation, the solvent action of the latter may lead to the formation of secondary deposits at the surface. This theory of origin has been advanced particularly by G. P. Grimsley to account for the earthy gypsum or gypsite that occurs in central Kansas. The secondary gypsum is a soft, incoherent, granular mass, found in low, swampy ground in the vicinity of bedded deposits. On microscopic examination the grains are found to consist of angular crystals that have apparently been formed in place. The secondary deposits of Kansas have much economic importance. The seams or veins which traverse beds of gypsum are also usually of secondary origin.

In the author's opinion, the theory of deposition from sea water is the only tenable explanation of the formation of large, interbedded deposits of gypsum. The reasons for this supposition are as follows: (1) Most of the great deposits are found interstratified with sedimentary rocks which show little evidence of metamorphism. (2) In no case, so far as has come to the knowledge of the author, has a fossil been found in gypsum deposits. In case the gypsum beds were the result of metamorphism or chemical change from beds of limestone, some trace would undoubtedly be found of the fossils occurring in the original beds of limestone. Even in cases of the most violent metamorphism of limestone, occasional fossils are found, so that the absence of these fossils in the beds of gypsum and the crystalline nature of all deposits, make it almost certain that these deposits were formed by crystallization from solution.

Geography and topography. The gypsum mines of the State are found near the southern border of the area of Salina rocks which may be called the Salina depression. It extends from Lake Erie and the Niagara river into Oneida county. The limits of this depression are marked on the north by the outcrop of the Niagara limestone, which forms a low ridge, known as the Niagara " escarpment."

The southern boundary is marked by the outcrops of the Onondaga limestone, though much of the drainage of the region covered by Devonian rocks passes through the depression. The extreme width of the depression is not more than 20 miles but the length is about 200.

Proof of the existence of this depression is to be found in an inspection of the map, where it will be noticed that there is an almost continuous line of creeks and rivers flowing in an east or west direction between the Niagara river and Utica. At only four points do these streams break through the Niagara escarpment, these four exceptions being the Oak Orchard creek, the Genesee river, Irondequoit river and the Oswego river. Taking the streams which drain this depression in their order from the east to the west, we find the Oswego river, which takes the drainage from Oneida lake and also from the Finger lakes; tributary to the Oswego river, the Clyde and Seneca rivers and Canandaigua outlet; west of the Finger Lake region, Honeoye creek, flowing west into the Genesee river, and then from a point near Leroy, Allen's creek, flowing east into the Genesee, while north of this, Black creek drains part of the Oak Orchard swamp and flows into the Genesee river; flowing west from Oakfield, the Oak Orchard creek, which breaks through the Niagara escarpment at Medina, while west of this, the Tonawanda creek completes the line across the State and takes the drainage of this part of the State to the Niagara river.

An examination of the topographic atlas sheets of this part of the State shows that there are many elevations within the Salina depression fully as high as the Niagara escarpment. The fact, however, that the drainage of the country overlying the Salina deposits extends in an east and west direction, and that the tributaries of the main streams flow south from the Niagara ridge and north from the Helderberg and higher deposits, gives unmistakable proof that there is here a valley about 180 miles long extending from the vicinity of Utica to the Niagara river. In some parts, the valley is double; this is to be seen west of the Genesee river, where we have Allen's creek and Black creek about 10 miles apart. In the Finger Lake region, it is also double, as is seen north of Seneca and Cayuga lakes, where the Seneca river and the Clyde river flow parallel to each other. In speaking of this region of the State as a depression, it is not the aim of the author to give the impression that it is a broad valley bounded by two ridges. It is rather a rolling plain with many small hills, few of them exceeding 100 feet in hight above the level of the valley.

Formation. Though there is now a marked depression, in former times the depth of the valley was much greater than at present, and, in order to determine the time and manner of its formation, it becomes necessary to consider the agencies that were active in cutting the valley and filling it again.

The continental ice sheet has been considered the most active agent in determining all slight irregularities in surface configuration; but, for reasons that will be set forth in another paragraph, it seems best to the writer to attribute the formation of the deep depression to preglacial streams, though the formation of the present slight depression is due to postglacial streams.

In order to prove that the original valley was formed in postglacial time, it would be necessary to show that streams with the power of Niagara had passed through this valley for a much longer time than has elapsed since the formation of the present Niagara gorge began. It also, would be necessary to show from what source the large deposits of gravel, sand and clay which fill this depression were derived and also why some of the lakes in central New York were not filled with these same deposits.

Geologists seem agreed in the supposition that, on the retreat of the Laurentian glacier, this region was covered with a succession of lakes, so that the theory of a great river cutting this valley in postglacial time may be discarded.

In the same way, we may discard the hypothesis that this valley was filled in postglacial time, as the filling material is largely sand and gravel from the Medina formation;[1] and, if it were derived from glacial debris at the south, the Finger lakes would show more traces of filling, and the deposits would be at the source and along the sides of these lakes rather than at their outlets; whereas there are no marked accumulations in these places that can not be explained in other ways.

The supposition that much of the cutting was accomplished by the glacier itself seems hardly tenable, inasmuch as the valley is at right angles to the line of glacial flow.

Before considering the question of preglacial cutting, a few facts must be noted, on which to base a theory that the valley was formed prior to the advance of the Laurentian glacier.

(1) Glaciers, in passing over a ridge like the Niagara escarpment, cut the ridge down nearly to the level of the adjoining strata. (2) The bottom of Lake Ontario is about 250 feet below sea level and is nearly at right angles to the direction of the

---

[1] Fairchild, H. L. Kame Areas in Western New York South of Irondequoit and Sodus Bays. Jour. of Geol. no. 2, v. 4.

glacial flow, and was probably formed by preglacial streams,[1] and in that case the land must have been several hundred feet higher to permit the cutting of such a valley. (3) The Mohawk river flows for a considerable distance over deposits of clay, sand and gravel several hundred feet thick.[2] (4) At Syracuse borings have shown that the deposits of drift are over 400 feet thick.[3] (5) South of Oneida lake and north of the Finger lakes are deep deposits of marl, which must have been formed since the glacial epoch.

Though soundings have not been made in all parts of the depression, the evidence that we have indicates a deep valley which is apparently tributary to the Mohawk river. For the present, the region west of the Genesee river will be left out of consideration, as the deposits of drift in that part are comparatively shallow, and there is presumptive evidence that the drainage was about the same as at the present time. Between Rochester and Lyons is a section which was not cut very deeply, as it was near the dividing ridge between the Genesee basin and the Finger Lake basin. From Lyons to Rome there is a sandy plain, underlain to a greater or less degree by glacial and lacustrine deposits, and the depth of these deposits indicates that at one time a great river must have been here.

Proof that the cutting of this valley was the work of a stream and not of the glacier is found in a comparison of the effect of the glacier on the other formations exposed to its action. Of these deposits there are three formations that are distinguished by their softness, the Medina shales and sandstones, the Salina shales and the Hamilton shales, and in the Salina is to be found the only narrow valley at right angles to the line of flow of the glacier. The Medina deposits at one time occupied a large portion of the territory now covered by Lake Ontario; and though much of the glacial drift is made up of fragments of Medina sandstone, it is generally conceded that much of the erosion of this formation was accomplished by a preglacial river. The Salina deposits, on the other hand, have a shallow valley at one part and a deep valley near by; and the presumption is that, if the deeper valley was made by glacial action, the shallow valley west of Rochester should be deeper, as it was exposed to glacial action longer than the Finger Lake region. In case the shallow valley was the result of glacial action, it still remains a question why the action should have been greater in the Finger Lake region. An examination of the Hamilton deposits shows no marked valley, and, as this formation was exposed to glacial action and is fully as soft as the others under consideration, it becomes almost certain that the Salina valley was not the result of glacial action.

---

[1] Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. N. Y. State Mus. Bul. 45. 9:47–51.

[2] Grabau, A. W. Geology and Paleontology of Niagara Falls. 9:46.
Carll, J. F. Pa. Geol. Sur. I^3:363.

[3] Geddes, George. Geol. Sur. of Onondaga. N. Y. State Agric. Soc. Trans. 19:277–79.

An. Rep't of the Superintendent of the Onondaga Salt Springs for 1884. p. 18.

The changes in level which these strata have undergone render it very difficult to determine with exactitude the direction of the ancient river, as it is supposed that the Finger lakes were formed in preglacial times by streams flowing south. The existence of this deep valley at the outlet of these lakes, however, leads the writer to suggest that at a stage between the time when the rivers flowed toward the south and the glacial epoch, the rivers in the Finger Lake valleys flowed into the Salina depression and thence through the Mohawk river.

While this valley was being formed, this part of the State was considerably higher than at the present time, as is shown by the fact that the bottom of the valley at Syracuse and the deepest part of Lake Ontario are below sea level, and valleys are not cut below the level of the outlet of the streams.

It is probable that the solvent action of water has had much to do with making this depression, and, if the existence of deposits of salt in this section could be proved, this would undoubtedly be a most logical explanation of the formation of certain parts of the depression. The existence of salt, however, in this region, is only a matter of conjecture, but in the region south of this, it is found in almost all cases where wells have been drilled through the Salina deposits. In a few cases where mines have been sunk through this formation, gypsum has been found interstratified with shale above the salt. In the Livonia shaft, three distinct beds of gypsum were encountered, while two were noted in the Greigsville shaft. In all these mines the combined thickness of the gypsum beds is from 60 feet to 75 feet, and in the Lehigh shaft at Leroy a single bed of gypsum 75 feet thick was passed through before reaching the salt. With the exception of the deposit at Fayetteville and Union Springs, no deposit has been found in the Salina depression to exceed 15 or 20 feet in thickness. It seems probable, therefore, that, when this part of the State was covered with water, the salt beds, if they existed here, were subjected to the action of water, and on their solution, crevices were opened up in the overlying strata, allowing rain water to have more ready access to the gypsum deposits. *That salt did once exist* in this valley, is almost unquestioned, because at many points saline springs are to be found, the most important being near Syracuse. Deep borings near Syracuse have however failed to reach any deposit of salt, but, on going up the valley south of Cardiff (about 15 miles south of the city) on both sides of the valley rock salt has been invariably struck, after passing through the Salina shales and limestones.

That the Salina depression has not yet been finished, and that the action of subterranean waters is still an important factor in extending its bounds, is evinced by the salt springs at Syracuse. These springs occur in a deposit of drift, and the only source from which the salt could be obtained is the beds of rock salt which are found about 15 to 17 miles south of Syracuse. Saline springs are found at many places in this depression, among which may be mentioned Montezuma, Greece, Lenox and Delhi.

The action of water in dissolving the gypsum deposits has been observed by several geologists, though in some cases this has been referred to other causes. The first case of this kind that was brought to the author's attention is to be seen at Indian Falls in the mines of the Standard Plaster Co. At these mines, when the first tunnel was being driven into the deposit, a pocket of clay was discovered, which seemed likely to cut off further mining operations at that point. Careful inspection, however, showed that both above and below this pocket of clay, were solid beds of gypsum. Further investigation showed that, at several points along the walls of the tunnel, smaller pockets ranging in size from a few inches up to three or four feet in diameter had been encountered. The shape of these pockets was much like an inverted hornet's nest or like a large jug with a small opening at the top, and through the opening the water had found its way to the gypsum, bringing with it clay, which replaced the gypsum as it was dissolved by the water. In all cases the clay is found to follow the same lines of stratification as the gypsum; and at first it was the author's opinion that the clay was residual, being left after calcium sulfate had been dissolved. In view of some of the larger pockets however and the nearness of the gypsum deposits at this point to the surface and the broken character of the overlying rock, it seemed certain that these pockets were caused by dissolving the gypsum deposits and replacing them with clay. Strength is added to this supposition by the fact that the limestone underlying the gypsum at this point is unbroken and has a slight dip to the south. The gypsum beds themselves are unbroken, but pockets are found throughout the deposit. The overlying strata, however, are much distorted and broken; but, in view of the lower strata having been subjected to no distortion, no other explanation is left for the broken character of the strata overlying the gypsum than a solution of the gypsum taking away the support from the overlying strata, which naturally would cause the strata to be broken by their own weight. Similar conditions have been noticed in quarries and mines throughout the State, and one case has been mentioned by Prof. S. G. Williams in the article which is quoted a little later.

The distribution of glacial debris in western New York sheds much light not only on the time of the formation of this valley, but on the manner and time of its filling. In the Finger Lake region there is a moraine at the head of each lake, which apparently corresponds with the one south of Dansville and Warsaw, but no other pronounced moraine is to be found in this region to correspond with the moraines extending from Lockport to Canandaigua or from Medina to Irondequoit bay. It seems probable therefore that, on the advance of the glacier to the Salina depression, the frontal moraine was dropped into the valley, bringing the level of the valley nearly to the level of the Niagara escarpment and giving a gentle incline, over which the glacier passed.

On the retreat of the glacier, several glacial lakes covered this region; and the general topography of this section is much like that around Oakfield, the entire depression being dotted with kames and drumlins. The absence of a moraine to correspond with the one from Medina to Irondequoit bay is probably due to the more rapid retreat of the ice at the eastern border, which would tend to form a more scattered deposit.

In a former paragraph, the writer made the statement that the drainage from this valley probably flowed into the Mohawk river; and, as the present drainage is toward Lake Ontario, this opinion may appear far-fetched. The reasons for this supposition are (1) that the level of this part of the Salina depression is about 125 feet above Lake Ontario, and, if there were an old channel, it would have been more likely that this would be left open than that a new channel would be formed. (2) The glacial debris is held in place by a ridge of Niagara limestone or the Medina sandstone, and this ridge was much higher in preglacial times. (3) The Rome channel is blocked up by glacial debris. Of these three reasons, the second is the only one that needs explanation and is possibly the most important.

As has been previously stated, the deepest part of the Salina channel is from Lyons to Rome and thence through the Mohawk valley, and to this is due the difference in the altitude of the Niagara escarpment in this section and the section west of Rochester. The tendency of the glacier being to bring the country to a level, it naturally follows that the erosive force would be greater in this section, where a narrow transverse ridge was placed between two deep valleys, than in the region west of the Genesee river, which had not been cut to a great depth. In this way the Niagara escarpment was cut below the level of the col at Rome, so that, when the St Lawrence channel was free from ice, the drainage from the Finger Lakes flowed over the lowest part of the Niagara cuesta into Lake Ontario instead of through the Mohawk to the Hudson.

Geology. The geologic position of the gypsum beds of New York State has been placed by most geologists in the Onondaga salt group of the Silurian system, or, as it is called, the Salina group.

Vanuxem describes this group as follows:

> This important group contains all the gypsum masses of western New York and furnishes all the salt water of the salines of the counties of Onondaga and Cayuga. From the point where the Niagara group terminates at the east, it rests upon the Clinton group; and, as the latter group also comes to its end near the first district, it reposes there upon the Frankfort slate, upon which it continues to near the Hudson river.
>
> It forms a part of the high range on the south side of the Mohawk; appearing at the north end of Otsego county and in Herkimer and Oneida, being its northern outcrop. It makes its first appearance by the side of the Erie canal at the east end of Madison county, and from thence west the canal was excavated in the group.
>
> The Onondaga salt group may be divided into four deposits. There are no well marked lines of division between the deposits; but for practical purposes the divisions are sufficiently obvious.
>
> The first or lowest deposit is the red shale, showing green spots at the upper part of the mass. 2d, The lower gypseous shales, the lower part alternating with the red shale, which ceases with this mass. 3d, The gypseous deposit, which embraces the great masses quarried for plaster, consisting of two ranges, between which are the hopper-shaped cavities, the vermicular limerock of Eaton, and other porous rocks. 4th, and lastly, Those rocks which show groups of needle-form cavities placed side by side, caused by the crystallization of sulfate of magnesia[1], and which may be called the magnesian deposit.
>
> The whole of these deposits are found between Oneida creek and Cayuga lake. To the east of the creek, they do not all occur, as will subsequently be made known. They thin out to the eastward and probably terminate entirely a few miles east of the Hudson river;

---

[1] Sulfate of lime most probably. [F. J. H. Merrill]

from which point their thickness gradually increases towards the west, and reaches its maximum in the counties of Onondaga and Cayuga, where it is not less than 700 feet. The gypsum has not been seen east of the western part of Oneida county. The red shale comes to its end at the east end of Herkimer county; and the whole group is reduced in the Helderberg in Albany county to a few feet of light gray or lavender-colored, compact calcareous rocks with pyrites, separating the Frankfort portion of the Hudson river group from the Waterlime series.[1]

Prof. James Hall[2] describes the Salina group as follows: Succeeding the Niagara group is an immense development of shales and marls with shaly limestones including veins and beds of gypsum. The general color is ashy approaching drab with some portions of dark bluish green. The lower part is of deep red with spots of green. Succeeding this, where protected from atmospheric influences, the rock is blue like ordinary blue clays, with bands of red or brown. This portion and that succeeding it are often green and spotted, and contain seams of fibrous gypsum and small masses of reddish selenite and compact gypsum. From this it becomes gradually more gray with a thin stratum of clayey limestone, which is sometimes dark, though generally of the same color as the surrounding mass. The formation terminates upward with a gray or drab limestone called by Vanuxem the "Magnesian deposit." The red shale forming the lower division of the group is well developed, but in the third district has not been found west of the Genesee river. It appears in the eastern part of Wayne county, as indicated by the deep red color of the soil which overlies it.

At Lockville a greenish-blue marl with bands of red has been quarried from the bed of the Erie canal. West of the Genesee this is the last of the visible mass. The red shale has either thinned out or lost itself, gradually becoming a bluish green, while otherwise the lithological character remains the same. On first exposure it is compact and brittle, presenting an earthy fracture. But few days are necessary to commence the work of destruction, which goes on until the whole becomes a clayey mass. The prevailing features of the second division of the group are the green and ashy marl with seams of fibrous gypsum and red or transparent selenite often embracing nodules of compact gypsum. The third division comprises all the gypsum beds of the fourth district which are of economic importance. In this third division hopper-shaped cavities occur in Wayne and Monroe counties, but rarely in Genesee or Erie.

---

[1] N. Y. State Mus. Bul. 11. 3:22-23.

[2] Geology of the 4th District.

There is scarcely any well defined division between the shales and shaly limestones of the third division and the so called magnesian deposit which overlies it.[1]

An investigation of the rocks near the plaster quarries at Union Springs has led Mr S. G. Williams to refer the gypsum deposits at this point to the Lower Helderberg; and his grounds for this supposition are here quoted in his own words.[2]

It is well known to geologists that the strata containing the gypsum deposits of New York, ranging from Madison county westward, at the time of the State Geological Survey were all assigned to the third of the four groups into which the Salina period was divided; and that these gypsum deposits were described as isolated masses of possibly concretionary character contained in the inclosing beds. The gypsum beds a short distance north of Union Springs, Cayuga co. are much the most extensive of these deposits. A recent examination of the gypsum beds and their inclosing strata, accompanied by some fortunate discoveries of somewhat abundant though often badly preserved fossils, has not only shown that the gypsum in this locality exists in continuous beds with a considerable degree of regularity, but has also afforded reasons for believing that this portion of the gypseous series belongs rather with the Lower Helderberg than with the Salina.

A section at this point eastward, and thus nearly in the line of strike, from the level of Cayuga lake to the top of the Oriskany sandstone, is about 114 feet thick and consists of the following members, numbered upward from the lake level.

No. 8	Oriskany sandstone in a single fossilferous seam	3 feet 8 inches
7	Drab limestone, upper beds with thin, undulating laminae: exposed	10 "
6	Limestone revealed only in occasional outcrops, leveled with Locke level, about	46 "
5	Thick bedded blue limestone, containing *Meristella laevis, Orthis oblata,* small form, *Rynchonella semiplicata, Strophondonta varistriata,* etc.	10 "
4	Drab limestone, holding a branching fucoid and *Nucleospira ventricosa*	4 "
3	Measures concealed, leveled with Locke level	20 "
2	Thin bedded blue limestone, terminating below with a seam 2 feet thick	4 "
1	Drab limestone unevenly bedded with two or three thin blue seams, to lake level	16 "

---

[1] N. Y. State Mus. Bul. 11. 3:24–25.
[2] Am. Jour. Sci. Sep. 1885.

The mean of four readings with the aneroid agrees well with the total thickness here given. The beds of no. 1 have yielded fossils at three points, all at about the same level near the middle of the series, viz: one head of *Eurypterus remipes,* and tolerably abundant *Leperditia alta, Nucleospira ventricosa* and *Meristella bisulcata.*

Besides the irregularities in the bedding of no. 1 mentioned in the section, the strata in this region are occasionally affected by local disturbances. The most common of these is a sudden tilting of the beds at a low angle, continuing sometimes a number of rods, which is caused apparently by a failure of support from below. One such disturbance occurs near the middle of no. 1, causing the beds to dip very perceptibly to the southward for a short distance. More considerable disturbances of a like character affect the Corniferous limestones of Union Springs, about 2 miles south of the plaster quarries, two of which have come under my notice. One of these, which was mentioned and figured in the report of the 3d district, and by which the limestone is caused to pitch suddenly south at an angle of 13°, has within the last two years been more fully developed by the opening of a large quarry immediately south of the disturbed beds. In this quarry, which is capped by a considerable thickness of Marcellus shales with a band of concretionary limestone, is revealed a flat-topped anticlinal arch with an E. W. strike, the southern limit of which has not yet been reached in quarrying, while the northward dipping side, with an angle of 20°, is near the junction with the southward dipping beds described by Vanuxem. In one of the most extensive plaster quarries also, there occurs a gentle anticlinal with meridional strike, through which the present working floor of this quarry and the one to the north of it, is made to dip eastward at a small angle as far as the workings extend; and if this dip continues, it will increase by a number of feet the space between nos. 2 and 4, which was found by leveling to be 20 feet. The knowledge of these occasional irregularities demanded caution in assigning the gypseous series, with an average thickness of 25 feet, to its proper place in the section, specially since the space of nearly a quarter of a mile between the fossil-bearing beds of the lake shore and the gypsum quarries, is concealed by drift. Fortunately the valley of a brook, separated only by a single field from the nearest quarry at this point, affords a continuous line of outcrop from the fossiliferous limestone on the lake to the top of no. 2, by which its continuity is assured. The top of no. 2 is 20 feet above the lake level, which is also the hight of the floor of the nearest plaster quarry. Add to this the fact that the character of no. 2 corresponds with that of the bed of tough blue limestone which forms the bottom of all the southern quarries, and there is no reason to doubt that the plaster series belongs in the covered space between no. 2 and 4, widened probably by the local easterly dip mentioned above, a position to which, in the absence of any local irregularities, it would be unhesitatingly assigned by any geologist.

There is then no doubt that the gypsum deposits here form a part of the fossiliferous series, lying above the beds containing *Eurypterus, Leperditia alta, Nucleospira ventricosa* and *Meristella bisulcata,* and below, or in close connection with beds containing well marked fossils of the Pentamerus and shaly limestone horizons of the Lower Helderberg. It should also be borne in mind that, apart from the gypsum beds, the entire section from the lake level to the Oriskany sandstone, is made up of drab limestones with frequent blue seams, sometimes of considerable thickness, as in no. 5. Some of these limestones, both at the bottom and top of the series, are highly laminated, showing thin layers of slightly different colors, and nearly all hold a considerable amount of impurities.

There is indeed, even if we set aside the fossil evidence now gained as to geological age, no such lithological change in the limestones as to warrant the reference of the lower portion of them to the Salina period, and the upper part to the Lower Helderberg. Nor is it likely that any such reference would ever have been made had it not been for the presence of the gypsum deposits. These deposits in the regions both east and west of Cayuga county appear, from the State reports, to occupy a pretty definite *place in strata bearing intimate relations with the shales* of the salt group; to occur in irregular masses inclosed in marly shales whose lamination they sometimes share and sometimes disturb; and to be divided often into two " ranges " by a peculiar porous or vesicular lime rock, or by shaly limestones, holding indications in hopper-shaped accretions of the action of saline waters. It was natural, therefore, in the absence of any evidence to the contrary, that the occurrence of gypsum in any additional locality not obviously removed from its usual horizon should lead to the reference of both gypsum and the accompanying strata to that horizon. A brief description of the gypseous series here however will show, I think, that its structure bears no very close resemblance to that of the gypsum of the Salina period; that its character is intimately related with that of the accompanying limestones; and that both character and structure tend to indicate for it a different geological horizon, if not a different origin from that of most of the other gypsum deposits.

It may be said at the outset that the gypsum deposits of this region are not irregular masses: they have no relations therefore with marly strata surrounding and inclosing them, they are not associated with any "vermicular lime rock" within them, nor with anything answering to the 4th or Magnesian division of the Salina lying above them. In one point only do they bear a superficial resemblance to the deposits elsewhere: they occur in two "ranges," or rather beds, separated from each other, however, not by shaly or vesicular lime rock, but by a bed called *slate* by the quarrymen, made up of thin seams of gypsum, interlaminated with other layers of shale.

The gypseous series here has a very uniform character, consisting as it does of three persistent and tolerably regular members. *First* occurs the lower seam of gypsum highly laminated and separating into several distinct layers, somewhat harder than the upper seam, and of a usual thickness of 7 feet, varying but little in this respect. *Second*, upon this rests a stratum about 3 feet thick called *slate* by the quarrymen, consisting of alternating laminae of gypsum and shaly matter, and said to be gypseous enough in the northernmost quarries (which are now little worked) to be ground for plaster. *Third*, the upper gypsum bed which closes the series, varies much in thickness, from nothing to upwards of 20 feet, averaging possibly 15 feet. Its variability in thickness is probably due mostly to denudation, since it is capped by yellow drift clay in nearly every place where it is laid open by workings. The upper gypsum bed shows little disposition to separate into distinct layers save in the northern quarries, and is softer and somewhat less dense than the 7 foot bed. It was thought to be of better quality until analysis showed it to be nowise superior. All the members of the series show occasionally small spots and thin, scalelike laminae of sulfur, more specially on dirt seams. The upper bed, I am told, contains more of the sulfur than the lower, and the slate seam more than either. The gypsum of both seams varies from a light to a somewhat dark gray.

The gypseous series here shows, therefore, no tendency to form isolated masses, save where denudation may give it that appearance, in which case it is enveloped in drift clay. Two proprietors of long experience, however, inform me that the entire set of beds is occasionally cut across by what are called "mud seams" from 1 to 5 feet wide, that the mud seams are often of a thin laminated structure and sometimes contain a little gypsum and selenite, and that the gypsum beds abut against them regularly on both sides. The only example of this kind of replacement that has come under my notice was in the edge of one of the quarries, where, at the time of my last visit, the lower gypsum bed and the *slate*, the only members there present, had suddenly given place to black, thin laminated mud, and above to harder, thin bedded ferruginous shale, the mud seams abutting against the gypsum and *slate* in a reentrant fashion. The lamination of the mud appeared to correspond to that of the gypsum against which it abutted, and one block was hard gypsum at one end and black laminated mud at the other, although elsewhere the gypsum and the mud were separated by irregular joint-like cracks. I was inclined to attribute the change to the action of water penetrating to the beds through crevices in the clay cover.

The limestone of that part of the series in question which encloses the gypsum beds is of a prevailing drab or ash color, with a few blue seams, of which no. 2 of the section is the only important one. It is often highly laminated, has a considerable amount of impurities as has already been said, and by reason of the earthy character of these impurities, it shows such a disposition to absorb water as to unfit it for all but the roughest purposes. A fragment of no. 1 gained in weight 3% by two hours' soaking, while a like fragment of the blue limestone no. 2 showed no appreciable gain in the same time.

The character of the limestones just described seems to me to throw light on the question of the origin of the gypsum beds; these I think have obviously been formed from the earthy drab limestone of the horizon at which they appear, as the result of the action upon them of acid waters originating in sulfur springs, which are still somewhat abundant in this region, and which it may be presumed were more abundant at an earlier geological date. The porous character of the drab colored limestones would facilitate such transformation, under favorable circumstances; while the imperviousness of the blue limestone which underlies the series would limit it below. Reasons for this opinion as to the origin may be found: *first,* in the striking similarity in structure between the lower gypsum and the associated drab limestones, both having the same highly laminated character, while both the lower gypsum and the northern part of the upper, are also distinctly bedded; *second,* in the structure of the intermediate bed, containing as it does alternate layers of gypsum and shale, as if whatever was lime in an impure shaly limestone had been transformed to gypsum, leaving the remainder unchanged; *third,* in the presence in all the gypsum beds of native sulfur, which would be difficult to account for on any theory of origin which would not include the action of sulfureted waters; *fourth,* in the composition of the gypsum itself, which is gray, and like the limestones somewhat impure, containing in commercial samples an average of 80½% of lime sulfate with 14% of earthy matter, 5% of lime and magnesian carbonates, and, quite significantly, .6% of lime phosphate and organic matter, these last ingredients suggesting an organic origin, while the residual lime and magnesia point to the probable original condition of the deposit. It may be added in this connection that in the limestone no. 1, in close proximity to one of the fossil localities and nearly at the same level, occurs a small isolated mass of decomposed gypsum, possibly 10 cubic feet in dimensions, which is due apparently to the agency of a small sulfurous percolation now extinct.

I believe, therefore, that the structure of the great gypsum deposits of Cayuga county separates them sharply from those existing elsewhere in New York in the strata of the Salina period; and that their associations with limestones, both below and above them, containing fossils of the lower divisions of the Lower Helderberg, as well as the nearly uniform character of the rock series from the lake level to the Oriskany sandstone, indicate for them a place in the lower portion of the Lower Helderberg in which I include the Waterlime group.[1]

Professor Williams's deductions in regard to the geologic position of the gypsum at Union Springs are apparently well grounded, but it seems that there is some difference of opinion as to where a geologic period begins. Apparently, Mr Williams considers the Lower Helderberg formation as beginning where the first fossils which are typical of these deposits made their appearance. If this ground be accepted, it will be necessary to refer the deposit at Union Springs to the Lower Helderberg. The general opinion of geologists, however, seems to be that the gypsum deposits of the State belong with the Salina group, and Dr J. M. Clarke has recently assigned the Tentaculite limestone to the Salina rather than to the Lower Helderberg, where it has been included for many years. In Luther's section of the Livonia salt shaft, the upper gypsum bed is referred to the Lower Helderberg. The lower and thicker deposits are referred to the Salina period; but, in view of the more recent opinion of Dr Clarke concerning the Tentaculite limestone, it is very likely that the upper gypsum bed at Livonia would also be referred to the Salina, and it would undoubtedly have been referred to this formation at the time when the section was published, were it not for the fact that Dr Clarke's idea of the geologic periods seems to have agreed with that set for them by Mr Williams, namely, that the geologic periods begin when the first fossils of that period appear.

---

[1] Williams, S. G. Geological Relations of the Gypsum Deposits in Cayuga County, N. Y. Am. Jour. Sci. September 1885.

The eastern limit of the known gypsum deposits is in Madison county, though rocks of the Salina group are found as far east as Schoharie. From Madison county to Buffalo more or less continuous deposits are to be found throughout the Salina depression. Most of the deposits that have been developed have been found in the hills rising above the level of the surrounding country, and as a usual thing the gypsum deposit does not have a great thickness. At Fayetteville the deposit reaches a thickness of 60 feet, and between Syracuse and Marcellus several thousand tons were taken out in making the railroad cuts on the Auburn division of the New York Central Railroad. The thickness of the latter deposit has not been measured, but from the outcrops that I have seen, I should judge that it is from 40 to 60 feet thick.

When the gypsum deposits of the State were first precipitated, they were undoubtedly continuous, but glacial action and the solvent action of water have taken away a great portion of the gypsum, leaving isolated deposits under a slight covering of rock or earth in a great part of the Salina depression.

The gypsum deposits are pierced by all the salt wells in the State outside of the Salina depression, but no information of value is obtained from a study of the well sections. The salt mines, however, give data that are very important.

In the shaft of the Livonia salt mine,[1] gypsum was found at a depth of 1078 feet in Lower Helderberg rocks. The deposit is 9 feet thick and is a mixture of gypsum and a so called marlite. At the depth of 1138 feet is another bed of gypsum 45 feet in thickness, while at 1278 feet is an 18 foot deposit with a band of shale separating it into two parts. The latter deposits are in the Salina formation.

---

[1] Luther, D. D. Livonia Salt Shaft. N. Y. State Mus. 47th An. Rep't. 1894. p. 215–324; N. Y. State Geol. 13th An. Rep't, p. 25–130.

The thickest deposit that is known in this State is in the Lehigh salt shaft at Leroy, where at a depth of 389 feet a deposit 75 feet in thickness was found. The rock is light colored in some parts, and samples that have been seen by the author compare well with the rock found at Oakfield and Garbuttsville. A project is on foot to make use of this deposit in the manufacture of stucco.

In the shaft of the Retsof mine at Retsof N. Y., a bed of gypsum 47 feet thick was found at a depth of 613 feet. This deposit is considered the top of the Salina in both the Retsof and Lehigh mines, though in the Livonia shaft it is supposed that the limestone and hard shale just above the 45 foot bed are Salina.[1]

It will be seen from these sections that the thickness of the deposit increases as we go south of the Salina depression, and from the appearance of this thick bed at practically the same horizon in these three mines, it seems reasonable to expect to find it throughout the greater part of western New York.

The future developments in gypsum mining in this State will probably be made south of the region from which the supply is now obtained.

HISTORY

The use of gypsum as a cementing material has been known for at least 4000 years, as shown by an analysis of the mortar used in the construction of the pyramid of Cheops, and that this use was known among the ancient Greeks is shown by the writings of Theophrastus and others. The precise date when this material was first used in this way is not known. Theophrastus records that plaster casts were first made by Lysistratus, but little use was made of the discovery, and the art was lost. This use was revived by Verocchio about 1450 A. D. and was of service in making copies of ancient sculpture which were discovered about that time.

---

[1] Luther, D. D. Report on the Geology of the Livonia Salt Shaft; N. Y. State Geol. 13th An. Rep't 1894. p. 25–130. Also N. Y. State Mus. 47th An. Rep't, p. 215–324.

The use of compact gypsum or alabaster was quite common in ancient times, and frequent references are made to it in ancient books. It was chiefly employed in the manufacture of urns, vases and other ornaments. Slabs of alabaster were sometimes used for windows, and the Romans used plates of the transparent gypsum or selenite for this purpose.

The industrial development of the last 20 years has been marked by a most wonderful increase in the use of gypsum. Up to that time the demand for raw gypsum in the United States was almost as great as that for plaster of paris, and the use of the latter article was very limited. With the discovery of processes by which the set of stucco may be retarded and the hardness of the finished product increased, plaster of paris has replaced lime mortar to a great extent as a wall plaster. Another factor in the increased production of this material is found in its use in Portland cement to retard setting.

In the year 1885 Prof. Carl Straub, then of Syracuse N. Y., patented a fluid composition for retarding the set of plaster of paris and at the same time hardening the material. Early in the next year (1886) he obtained another patent for a dry compound to be used in the same way. This was the starting point of the hard wall plaster industry in this country. Professor Straub associated with himself Mr S. S. Ruston, and under the firm name of Straub & Co. the first business of manufacturing hard wall plaster was established at Syracuse. The new material met with favor from the start, and in January 1887 the Adamant Manufacturing Co. was organized with a greater capital and took over the plant and business of Straub & Co.

At the outset only Nova Scotia and European gypsum were used, as at that time one of the things much desired was to have a white, smooth surface to the wall. The demand, however, for a wall plaster having the advantages of plaster of paris in the matter of quick setting and freedom from shrinkage, so that a building could be more quickly occupied than when a lime plaster is used, caused manufacturers to experiment with the gypsum of New York and other states with a view to utilizing it for this purpose. It was found that in all places where absolutely white finish is not required the New York gypsum was fully equal to the imported in strength and setting qualities. As a consequence, mills were erected, and the manufacture of plaster of paris and wall plaster from New York gypsum was begun on a large scale. The erection of buildings for the World's Fair at Chicago and other expositions which have taken place in the last 10 years has probably had a greater effect on the gypsum industry than any other development. The thousands of tons used in the manufacture of "staff" would of themselves make quite a difference in the industry, but the greater effect probably came indirectly through the thousands of people who for the first time realized the strength and durability of this building material.

The sources from which the world's supply of gypsum is obtained are to be found in nearly every portion of the globe. The most important deposits in foreign countries are those at Montmartre, near Paris, and those of Nova Scotia. It is also found in various parts of Germany, in Norway, Austria, Bohemia, Italy, Egypt, Arabia, India and Persia. In the western hemisphere it occurs in nearly every great division. Fine deposits occur in Chili and other South American republics, while in the north it is to be found in the provinces of Ontario, Quebec, New Brunswick and Nova Scotia. Its occurrence in the United States is widespread, and there is scarcely a state in which it may not be found. From a commercial point of view the entire supply comes from the following states and territories, New York, Ohio, Michigan, Iowa, South Dakota, Kansas, Oklahoma, Wyoming, Colorado, California, Indian Territory, Arizona, Montana, Oregon, New Mexico, Texas, Utah and Virginia.

With the increased demand for this material, deposits which were formerly considered inferior have been opened up, new deposits have been discovered, and the product of this country finds a ready sale in competition with the best Nova Scotia gypsum.

In this State the development of the gypsum deposits followed close on the settlement of the country, but the date when gypsum was first mined is not known. The deposits at Fayetteville were opened in 1812; and in 1822 Cleaveland stated that "In the western part of New York, sulfate of lime is very abundant, particularly in Onondaga and Madison counties, and in the vicinity of Cayuga lake, whence several thousand tons are annually exported to Pennsylvania." Though statistics of production are not available for the greater part at this time, there is little reason to think that there were any marked fluctuations in the product other than those caused by differences in climatic conditions and a natural growth. Since 1889 it has been observed that there is little variation in the quantity of land plaster used from year to year, and this was practically the only form in which gypsum from this State was marketed prior to 1890.

USES

The purposes for which gypsum has been used since it was first discovered are numerous and varied. In its natural state it was used as a building stone at a very early date, on account of the ease with which it could be dressed. Examples of its use in this way were the temple of Fortuna in Seia and the buildings of Arsoffa Emii in Arabia.

The transparent plates of selenite were used by the Romans in place of glass for windows, and translucent slabs of alabaster were used at a later date in some buildings for the same purpose.

Alabaster and satin spar were used at an early date in making ornamental vases and similar ornaments, and at the present day they are still cut for this purpose in Germany and Russia. When cut *en cabochon,* satin spar has the chatoyancy of cat's-eye, but can not be used as a gem on account of its extreme softness. When ground to a powder, it is used without calcining as a fertilizer, as an absorbent and deodorizer, as an adulterant and in the manufacture of glass and porcelain.

As a fertilizer, gypsum has long been used in the powdered condition under the name of land plaster. Its use in this country was, it is stated, largely the result of the efforts of Benjamin Franklin, who is reported to have sown plaster on a clover field near one of the principal roads in Pennsylvania in large letters so as to form the sentence, "This has been plastered with gypsum." The clover which had been plastered was greener and more thrifty than that which had not received an application of the plaster, and the letters were distinctly visible at some distance.

Probably the action of no fertilizer is so little understood as is that of gypsum; and those who have used it are in some cases enthusiastic in its favor, while others are just as pronounced in their opposition to its use. It is a question whether it has any direct fertilizing value, though the ashes of nearly all the plants contain varying percentages of lime and sulfuric acid which were possibly derived from gypsum. Its value as a fertilizer is attributed by Liebig to its power of fixing ammonia from the atmosphere so as to make it available as plant food.

It is the opinion of De Candolle that gypsum is a stimulant to the leaves of plants; while Chaptel considered the stimulating effect to be due to the saline character given to the sap of the plants.

Sir Humphrey Davy regarded gypsum as a direct source of plant food, because a certain percentage of sulfate of lime is found in the ash of plants; but the most satisfactory explanation of its action is the theory advanced by Storer, which supposes a threefold action, the first mechanical and the others chemical.[1]

1 The salts of lime have a tendency to flocculate loose soils, making the soil more granular, while an opposite effect is observed on clay soils where the soil is broken up into finer portions. Gypsum as a salt of lime acts to a slight extent in this way, but other lime compounds act much more rapidly.

2 It is supposed that gypsum gives up part of its oxygen to certain organic substances in the soil, thus preparing them for plant food.

---

[1] Storer. Chemistry of Agriculture. 1887. 1:206-16. Quoted by Grimsley, Gypsum Deposits of Kansas, p. 132.

3 Gypsum decomposes the double silicates of the earth, setting free potash as a double sulfate. This action according to Storer is as follows:

$$\left.\begin{matrix}Al_2O_3\\CaO\\K_2O\\H_2O\end{matrix}\right\} x\ SiO_2+CaOSO_3=\left.\begin{matrix}Al_2O_3\\CaO\\CaO\\H_2O\end{matrix}\right\} x\ SiO_2+K_2O\ SO_3$$

In this way potash is furnished in solution to the roots of the plants, but a similar result should follow the application of quicklime, with the difference that potash would be set free as K_2O, which would unite with carbon dioxid, which is present in all natural water, forming the carbonate, instead of sulfate.

In considering the mechanical effect of lime salts on the soil, it is to be noticed that the action on sandy or gravelly soils is entirely distinct from the action on tough clay soils, but in each case the soil is made more granular.

The lime undoubtedly has no material effect in either case till it is in solution, and it seems probable that the effect on the clay soil is due almost entirely to the chemical action of the salts of lime on the potash occurring in the clay. The action of lime on loose sandy soils has been illustrated by placing lime in a muddy liquid, whereby the mud flocculates and falls to the bottom. This, however, does not seem to be a satisfactory explanation of the action of the lime on the soil, inasmuch as, when such flocculation takes place as is seen when lime is put into muddy water, it is largely due to the fact that alum compounds have a tendency to precipitate both solid and dissolved materials in any liquid in which they may be found. This reaction is probably due to the chemical change noted above, by which the lime is rendered insoluble and the potash set free. In this case the particles of the new compound of lime are likely to be more compact than the clay or the solution of lime, so that they more readily fall to the bottom. The flocculation observed in sandy soils is due largely to the action of the lime on the clay which is almost invariably found in these soils.

The effect of lime in gravel beds may be noticed when such a deposit is uncovered; for even in dry seasons the pebbles are found in many cases to be covered with a slimy material which on exposure to the air, becomes solid. This in most cases is a salt of lime, usually the bicarbonate, though the sulfate would have much the same effect. A coating of such slimy material has an important chemical action on the pebbles with which it is found, if these be slate, shale or flagstone; for in this case, the lime acts on the potash in these rocks in the same way that it would on the potash in clay. In some soils particles of glauconite or green sand are present, and, as this substance contains an appreciable amount of potash, which in its natural state is only slightly available as plant food, the salts of lime would have an important effect in setting free this potash.

The amount of moisture retained by a sandy soil where lime salts are not present is nearly if not quite as great as where they are absent, so that the theory that gypsum absorbs moisture and stores it for plant food may be discarded, and the treatment of its action on the constituents of the soil may be taken up under the third heading. As a matter of fact, gypsum does not take up water; but as has been stated before, water dissolves gypsum, and, when the water evaporates, the gypsum separates in its former condition.

The theory noted above, that gypsum gives up part of its oxygen to organic substances to promote decomposition, seems to be without foundation, as the experiments of Sir Humphrey Davy show that not the slightest difference in the time of putrefaction can be noted between meat treated with gypsum and that not so treated. That gypsum does absorb ammonia or change it to the sulfate is an unquestioned fact, and it may well be employed about stables as an absorbent of this valuable fertilizer; but that it promotes the formation of ammonia seems to be disproved by Davy's experiments.

The chemical action of gypsum and other salts of lime in setting potash free from insoluble compounds is undoubtedly the only tenable explanation of the wonderful results following their use; and the material so acted on is usually clay, which is essentially a hydrated silicate of aluminum with certain percentages of potash and soda, and is derived from the decomposition of the feldspar of granite rocks. Shale and slate are modified forms of this material and are acted on in the same way as the clay in its plastic form.

In the greensand region of New Jersey I talked with a farmer, who said that he had for many years used greensand, but that, as time went on, he failed to get a proportionate increase in the crops from the application of this material. He gave a light coating of lime to a meadow, and on that portion where the lime was applied, the crop was nearly twice as heavy as on the portion not so treated. Inasmuch as greensand marl contains about 3% of potash, the explanation seems to be that the lime set the potash free, with a marked increase in the crop.

Boussingault discovered that an increased percentage of potash in the ashes of clover was apparently the result of the application of gypsum to the soil. His experiments carried on for two years on the same land gave the following results.[1]

	1841		1842	
	Land with gypsum	No gypsum	Land with gypsum	No gypsum
Ashes free from CO_2............	270	113	280	97
Silica..........................	28.1	22.7	10.4	12.7
Oxids (iron manganese and alumina)......................	2.7	1.4	(?)	.6
Lime...........................	79.4	32.2	102.8	32.2
Magnesia......................	18.1	8.6	28.5	7.1
Potash........................	95.6	26.7	97.2	28.6
Soda...........................	2.4	1.4	.8	2.8
Sulfuric acid..................	9.2	4.4	9	3
Phosphoric acid...............	24.2	11	22.9	7
Chlorin........................	10.3	4.6	8.4	3

From the foregoing it will be seen that the best results from the application of gypsum will be obtained from the application to soils containing potash in an insoluble form.

---

[1] Storer. Agricultural Chemistry. 1887. 1:206, 216, Quoted by Grimsley, Gypsum Deposits of Kansas, p. 127.

As an adulterant it is sometimes known as "terra alba" and is used in food and medical preparations.

In the calcined state, as plaster of paris, the uses of gypsum are too numerous to catalogue, but the greater part of the product is used in wall plaster and in wall washes. Dentists use large quantities in making plates, surgeons use it to hold broken limbs in place, and sculptors find it an invaluable material for making masks and casts. To the antiquary it is invaluable in taking impressions of inscriptions, statuary etc. It is used to some extent in the manufacture of wine to retard fermentation (the plastering of the wine) and absorb water. It has been discovered that blocks of plaster of paris are a good fireproofing material, because of the fact that it is a bad conductor of heat, being said to be superior to hollow brick.

It has ordinarily been supposed that the manufacture of slow setting, or cement, plaster is a new feature of the gypsum industry, but comparative analyses of the cement used in the building of the pyramid of Cheops and the modern cement plaster show a remarkable similarity in composition. Whether these two cements had the same chemical composition when prepared for use is a question, as slightly overburned or underburned gypsum will absorb water and return to the original condition, but much more slowly than gypsum that is properly burned. It is supposed by some that the cementing material of the pyramid of Cheops was slower setting than the cement plasters.

The difference between ordinary plaster of paris and a cement plaster is brought about by the addition of some retarding material to the plaster of paris, so that it will not set so soon, ordinary plaster of paris requiring only a few minutes to become hard, while a cement plaster requires from two to 24 hours to become thoroughly hard.

It is of interest to note that, whereas New York State plaster of paris was considered of no value but a few years ago, at the present time most of the mills have difficulty in filling their orders. With the increased use of gypsum cement plaster, the old lime plaster is being largely driven from use. The slightly gray color of some of the New York State plaster was long urged as an insuperable objection to its use, but, when mixed with sand and fiber, it makes a superior wall plaster.

The advantages of cement plaster over lime plasters are, *first,* it sets more rapidly and dries out more rapidly than lime plaster, so that there is less delay in finishing buildings, *second,* as a nonconductor of heat, it is valuable as a fireproofing material, *third,* any desired tint can be given the plaster by mixing it with coloring material at the time the plaster is prepared for putting on the wall, *fourth,* less mortar is required to cover the same amount of wall space, *fifth,* it may be used in large slabs in wainscotings, as a substitute for marble and other ornamental stones, *sixth,* it is less liable to shrinkage than other plasters, so that few cracks are to be seen in the walls covered with this material.

Among the objections to the use of this plaster are its greater cost and the facility with which sounds are conveyed through walls of this material.

As just stated, the cement plasters have certain fireproof qualities, and these are increased by certain admixtures. Mixed with asbestos, it has been used in plastering the inside of firepots in stoves; in the walls and floors of fireproof buildings it has been used mixed with ashes and asbestos. In some cases the plaster of paris is mixed with wood fiber and other material and molded into blocks which resemble in form and appearance the hollow terra cotta fireproofing material. These are of course used in exactly the same way as the terra cotta.

The use of plaster of paris and the cement plasters in making ornamental ceilings and stucco work in general is becoming very widespread with the regulation of the set of the plaster. For this purpose, instead of laying the plaster on lath surfaces, the stucco is molded in the shop of the artist and is nailed or otherwise fastened to the timbers or girders of the walls or ceiling. The separate pieces are made in specially prepared molds of glue, and fiber is added to give strength and toughness, while strips of wood are laid crosswise in the back of the larger pieces to give rigidity and in some cases to afford a better means of fastening the piece to the wall or ceiling.

A more recent development of the gypsum industry is the manufacture of wall boards made from alternating layers of paper and plaster of paris. The process of manufacture consists in spreading the properly moistened plaster of paris on the surface of a sheet of building paper, above the layer of gypsum is then placed another sheet of paper, and the two layers of paper and the one of gypsum are then passed between rolls, after which another layer of gypsum is spread above the second sheet of paper, a third sheet of paper is added and the rolling process continued. This operation may be repeated an indefinite number of times, but the usual practice is to have from five to seven layers of gypsum. When the board has passed from the machine where it is made, it is conveyed down a long table, where it becomes partially hard and is cut into the proper size for use. In order to give the material a chance to dry without warping, it is suspended from supports from the ceiling. When dry, the boards may be nailed to studs and rafters in the same way as boards or lath.

In the manufacture of glass, gypsum takes a very important part. In the uncalcined state it is said to be used as a constituent of certain kinds of glass. Its most important use, however, is in the calcined state, when it is used in plate glass factories to form a bed on which the glass is placed for polishing. In this way the strain is taken from the glass and there is little liability of breakage.

In monumental work, plaster of paris finds a similar use when it is placed about the stone to be polished, to form a bed for catching the water and polishing material.

The use of plaster of paris as a flux[1] is but little known, but in melting brass it is found to be superior to any known flux. It melts easily, gives off no obnoxious fumes and is easily removed from the ingots. In practice it is the custom to use about 5 pounds of the plaster to every 100 pounds of brass.

---

[1] Sperry, E. S. Aluminum World, March, 1902.

Portland cement

A certain part of the plaster of paris made in this country is used in the manufacture of Portland cement. This use is legitimate up to 2%, but above that point it acts as a diluent, and the practice is to be condemned. The effect of plaster of paris on Portland cement is shown in the following, quoted from bulletin 44, New York State Museum.

> The raw materials used in the manufacture of Portland cement may sometimes contain sulfate of lime in the form of the mineral gypsum, or sulfur may be present in the form of pyrite, which in burning tends to react with some of the carbonate of lime, yielding calcium sulfate. A similar effect may be caused if there is much sulfur in the fuel used. The effect of this sulfate of lime, if it does not exceed 2% or 3%, is to greatly delay the setting of the cement and also increase its final strength somewhat. If present to the extent of 4% or 5%, however, both these qualities disappear, since formation of calcic sulfid is brought about, which in turn reacts with the iron compounds in the cement and tends to disintegrate it. The effect of sulfate of lime is shown in the accompanying table, taken from Professor Johnson's work, *Materials of Construction,* p. 187.
>
> The German association of Portland cement manufacturers has declared against any addition except up to the 2% $CaSO_4$ to regulate setting time. It is the general practice in the United States now to put in 2% $CaSO_4$ to produce slow set.
>
> The following experiments are quoted by Lewis, showing the effect of sulfate of lime on the rate of setting.

No.	ONE SORT OF CEMENT	SETTING TIME		NEAT-CEMENT BRIQUET					BRIQ. 1 CEMENT, 3 SAND				
		h.	m.	7 days	28 days	12 weeks	25 weeks	1 year	7 days	28 days	12 weeks	25 weeks	1 year
1	As manufactured	0	20	323	405	518	620	700	115	168	238	302	360
2	Same w. .5 gypsum	3	30	315	456	572	623	650	142	212	339	353	390
3	1 gypsum	10	0	375	508	568	695	780	159	238	311	368	384
4	2 gypsum	14	0	423	543	688	718	805	180	263	305	375	410
5	No gyp. but kept in store for some months	10	30	318	450	550	592	618	168	218	318	360	431

These results were reported by John Grant in 1880.

MIXTURE	7 days	31 days	60 days	90 days
1-1 briq. average of 5........	107	159	188	267
1-1 briq. w. H_2SO_4 added to water: average of 5.......	129	227	260	255

Professor Tetmajer in 1894 reported these results.

No.	Per cent of plaster paris added	Strength of sand briq., 1 to 3 lbs. per sq. in. 3 days	7 days	28 days
4	......	......	160	240
	1	......	212	298
	2	......	167	254
5	......	174	285	307
	.5	225	305	344
	1	227	320	408
	1.5	230	381	399
	2	182	290	400
	2.5	184	295	390
	3	115	235	360

The results reported by Candlot in 1891 were as follows:

MORTAR	Days	SULPHATE OF LIME 0% lbs.	1% lbs.	2% lbs.	3% lbs.	4% lbs.
Neat cem. briq............	7	485	645	533	435	264
	28	673	738	674	790	483
1 cem. to 3 sand briq......	7	223	252	263	185	126
	28	333	377	377	367	201

Lewis considers these results remarkable as regards strength and not explained.

PROCESSES OF MANUFACTURE

About the middle of the last century the greater part of the best stucco for casts was made by the artists to secure the proper temperature in burning. In this way the artist was also enabled to make sure that the plaster had not lost its property of quick setting through absorption of water from the atmosphere.

Usually this calcining was done in small kettles over a domestic fire, and the gypsum was powdered before being cooked. In some cases the cooking was done on a metallic plate instead of a kettle.

Frequently the gypsum was baked in the baking oven,[1] or, as it is better known, a brick oven. In this case the rock was broken to the size of an egg and spread out on the sole of the oven. Such an oven had no separate fireplace, but a fire was kindled on the sole, and, when the oven reached the proper temperature, the coals and ashes were removed and the gypsum was thrown in, and the door closed. From time to time pieces were taken out for trial, and, when they exhibited on the fractured surface only a few shining crystalline particles, the charge was removed and ground.

---

[1] Knapp. Chemical Technology. Phil. 1849. 2:400-12.

At Paris, where the manufacture of calcined gypsum, or plaster of paris, was for a long time carried on more extensively than in any other one locality, special plaster kilns or ovens were employed for baking the gypsum. The kiln was rectangular in form, covered with an arch and inclosed with side walls and also a wall at the back in which the chimney was erected. The front was left open for convenience in discharging and regulating the fire. The fireplaces were always constructed afresh in these ovens, and the largest lumps were used for this purpose, and smaller pieces were thrown on above. Wood fires were used in this kiln, and the smoke escaped through openings into the chimney.

In such an oven a certain percentage of gypsum was of necessity ruined, a part being overburned and another part being changed to calcium sulfid. A kiln very similar to the foregoing was used with coal as a fuel, but a special chimney was not used, and a grate of brick was built so as to permit the removal of ashes. The front was left open, but the gypsum was introduced through a door at the rear. Beneath the arches of gypsum were brick arches on which the coal was placed while the ash fell through the perforated bottom. The burning occupied from 12 to 16 hours when the lower layers were free from water. This type of kiln was open to the same objections as the earlier type, and a great proportion of the plaster was dead burnt, so that it would no longer set.

The kiln used by Scannegatty, though similar in some respects, is far better than the previous types, because the coal is not in contact with the gypsum, and the liability of forming calcium sulfid is reduced to a minimum. The entire inner chamber is divided into two unequal parts by an arch, situated about a foot from the bottom. The upper part, into which the gypsum is introduced, is provided with eight draft holes. The lower chamber, or fire surface, is situated in front of the kiln. The draft channel terminates in the ash pit under the grate, on which a coal fire is made.

The flame enters below the perforated arch, where it is uniformly distributed over the whole area of the kiln in an upward direction through the gypsum, and makes its escape through apertures. The capacity of this kiln is given as 220 cubic feet of gypsum. Dumesnil's oven resembles Scannegatty's in form and in the manner in which the heat is applied, but would seem to be less economical of labor, though more heat is saved.

After the gypsum was calcined by any of the foregoing processes, it was reduced partially to powder, but the bulk of it had to be ground and sifted to separate the coarse particles.

In New York there are 18 mills engaged in the manufacture of land plaster and in the manufacture of plaster of paris from New York State gypsum. Two processes, the Cummer and the kettle, are employed in the manufacture of plaster of paris. So far as the land plaster is concerned, the process by which it is made is the same as the first steps in the kettle process of making plaster of paris.

The machinery used by most of the mills is made by Butterworth & Lowe of Grand Rapids Mich., and F. D. Cummer of Cleveland O.

Kettle process. As a rule, the crusher, which is usually an ordinary jaw crusher, is placed on the ground floor of the mill, so that the rock may be thrown directly from the wagon or car into the hopper. Pieces up to about a foot in diameter are reduced in this crusher to pieces of about 2 or 3 inches in diameter and are then taken to the nipper.

The nipper resembles an old-fashioned coffee mill, to a certain extent. The upper part, however, consists of a corrugated hopper in which a corrugated cone rotates, crushing the pieces of gypsum to about the size of a hickory nut. The lower part breaks them up to about the size of peas, after which the fragments are elevated to a bin on the floor above. From this bin material is drawn through spouts to the burstones, which are usually on the same floor as the crusher. Other processes of grinding the gypsum have been introduced in other states, but so far the improvements have not been introduced into the mills of this State.

After the gypsum has been ground, it is elevated to the storage bin, which is located on the top floor of the mill, so that the kettles may be filled from it by merely opening a gate and letting the plaster run by gravity from the bin. The kettles consist of cylinders of boiler steel, usually 8 feet in diameter and 6 or 8 feet deep. Such a kettle is estimated to hold 10 or 12 tons, though usually the charge is not more than 8 tons.

For greater strength the bottom of the cylinder is convex upward and is thicker than the sides. The kettle is placed on a brick foundation and is enclosed in a brick jacket with an air space between, which serves as a flue. Two flues pass through the kettle, so that more heat is saved on account of the greater surface exposed to the heat. The gypsum is stirred from the time it is first put into the kettle till the charge is withdrawn by the two arms near the bottom of the kettle, which are fastened to a vertical shaft, which is set in motion by a pinion wheel. The plaster is fed gradually into the kettle, because, if it runs too rapidly, the gearing may be broken and the plaster burned on the bottom. It takes about an hour to fill the kettle, and in a short time the temperature of the plaster reaches the boiling point of water, and part of the water of crystallization begins to pass off. When the temperature reaches about 235° F., the mass boils furiously, and the temperature gradually increases to about 260° F., when the vapor ceases to pass off and the plaster settles into a solid mass. When the temperature rises to about 290° F., the boiling begins again, and the plaster continues to give off water till the temperature of 350° F. is reached, when it settles again. At this point a gate is raised, the plaster rapidly discharged into a bin on the ground and the kettle again refilled.

The plaster is now bolted or screened, and the coarse particles are reground in burstone mills.

The Cummer process. The first stage in this process is the same as the first stage of the kettle process: i e, crushing in a Blake crusher to about the size of a hickory nut. Usually a nipper is not used, but the rock is screened after being crushed, and pieces that are larger than the desired size are returned to the crusher and broken again. In some mills gyratory crushers are used, and, where a large quantity is to be crushed, these are probably more economical than the jaw crushers.

The crushed rock is elevated by a bucket elevator to the storage bin, from which it is drawn by gravity to the calciner, which consists of a cylinder of boiler steel about 27 feet long and 4 feet in diameter, which revolves over the fire. The fire is usually fed by self-stoking machinery, and the smoke passes through the cylinder, so that as much heat may be saved as possible. The cylinder is inclined slightly, so that the material rolls from the inlet to the other end, where it is taken by a bucket elevator to the cooling bin. When the material in the bin becomes cool enough, it is withdrawn through gates at the bottom and conveyed to the mills in which it is ground. In the plants using the Cummer process, emery mills are used in place of burstones, because they do not require redressing so often. After passing through the emery mills, the plaster is screened and the larger particles are returned to the mill to be reground.

TECHNOLOGY OF GYPSUM

Though, as heretofore stated, the use of gypsum as a cementing material was known at an early date, and its application to the soil as a fertilizer was also known, yet the most of the properties of this material, together with its chemical composition, were unknown and had never received any investigation. The discoverer of the composition of gypsum was Lavoisier, who in 1765 published the results of his experiments in the Proceedings of the Académie des Sciences. After decomposing the gypsum rock and discovering the chemical composition, Lavoisier produced gypsum by synthesis.

Physical properties of gypsum. Sufficient has already been said about most of the physical properties of gypsum [p. 91 et seq.], but the results of recent experiments render it necessary to go more deeply into the subject of the solubility of gypsum.

A table has already been given showing the results obtained by Marignac, and, for the average reader as well as the author, it will seem more practical than the more recent table which has been prepared to show the number of millimolecules of gypsum in a liter of a normally saturated solution. The results of Poggiale, Marignac and Droez have been calculated to millimolecules per liter.

Temp.[1]	Poggiale	Marignac	Droez	Normally saturated solutions Hulett and Allen
0°	15.06	14	.....	12.91
5.5	.....	.....	14.11	13.56
14.2	.....	.....	14.83	14.50
18	.....	15.06	.....	14.81
19.5	.....	.....	15.66	14.88
20	17.72	.....	.....	14.95
24	.....	15.30	15.87	15.23
32	.....	15.64	.....	15.38
35	18.75	.....	.....	15.40
36	.....	.....	16.19	15.41
38	.....	15.79	.....	15.41
41	.....	15.71	.....	15.39
53	.....	15.52	.....	14.85
72	.....	14.86	.....	12.70
86	.....	13.94	.....	12.70
99	.....	12.89	.....	11.95
100	.....	.....	.....	11.90

Lavoisier discovered in his experiments that, on heating gypsum, water was removed at two different stages, and furthermore that, while it was a simple matter to remove three quarters of the water, it required more time and much higher temperature to force out the remaining quarter.

In 1830 these results were confirmed by Payen, who found that water commences to pass off at 115°C., and that the loss continues up to 204°C. The most extensive experiments, however, were probably made by Le Chatelier.[1] As a result of these experiments, it was discovered that from the boiling point of water up to 200°C., the rise in temperature was constant with two exceptions. The first halt occurred at 128°C., the second at 163°C. From this fact and the fact that water ceased to pass off at these stops, he inferred that there are two different hydrates which are decomposed before any rise in temperature takes place.

---

[1] Hulett, George A. & Allen, Lucius E. The Solubility of Gypsum. Jour. Am. Chem. Soc. July 1902. v. 24.

In order to prove the existence of two hydrates, Le Chatelier heated a saturated solution of gypsum in a closed tube to a temperature between 130°C. and 150°C. As a result, delicate rectangular prisms were formed, which, when analyzed, gave the following result:

Water	6.7
Sulfate of lime	93.3
	100

A result was obtained in this way which corresponds very closely to an analysis of the incrustation in the boilers of ocean steamers, in which the analysis made by Le Chatelier was as follows:

Lime carbonate	.3
Iron oxid	2
Water	5.8
Lime sulfate	91.9
	100

These results both agree very closely with the formula $(CaSO_4)_2 H_2O$, which would show the analysis

Water	6.2
Sulfate of lime	93.8
	100

---

[1] Le Chatelier. On the Dehydration of Gypsum stone and the two Compounds Formed. Académie des sciences. Comptes rendus. 1883.

Set of plaster. Lavoisier, Landrin, and Le Chatelier all gave theories to show the cause of plaster of paris setting or becoming solid.

Lavoisier's theory, as quoted[1] by Grimsley from the original account, is as follows:

I took the calcined plaster, as has been described before, and which hardens readily with water. I threw it into a considerable amount of water, in a pan or in a large dish. Each molecule of plaster, in passing through the liquor, seized its molecule of water of crystallization and fell to the bottom of the dish in the form of small brilliant needles, visible only with a strong lens. These needles, dried in the free air or with the aid of a very moderate heat, are very soft and silky to the touch. If placed on the stage of a microscope, it is perceived that what was taken under the lens for needles are also parallelopipeds, very fine, so they are described as thicker, or many thinner, and many more elongated. The plaster in this state is not capable of uniting with water, but if it is calcined anew, these small crystals lose their transparency and their water of crystallization, and become again a true plaster, as perfect as before. One may in this fashion successfully calcine and recrystallize the plaster, even to infinity, and consequently give to it at will the property of seizing water.

Landrin's[2] theory, which is the result of an elaborate study of plaster, divides the set into four periods:

1 The calcined plaster, on contact with water, unites with this liquid and takes a crystalline form.

2 The plaster dissolves partially in the water, which becomes saturated with this salt.

3 A part of the liquid evaporates, due to the heat set free in the chemical combination. A crystal is formed and determines the crystallization of the entire mass; a phenomenon which is analogous to that which takes place when a piece of sulfate of soda is placed in a saturated solution of this salt.

4 The maximum hardness is reached when the plaster loses enough water to correspond exactly to the formula SO_3CaO, $2H_2O$; this maximum being to the remainder in proportion to the quantity of water added to the plaster to transform it into mortar.

---

[1] Landrin. Annales des chimie. 1874. p. 434, 435. Also Grimsley Gypsum Deposits of Kansas, p. 90.

[2] Landrin. Annales des chimiê. 1874. Also Grimsley Gypsum Deposits of Kansas, p. 91.

Le Chatelier's theory. Le Chatelier showed that Landrin's third principle as mentioned above was not necessarily true, inasmuch as plaster would set in a vacuum flask.

His own theory was that plaster of paris partially dissolves in the water, thus diminishing solubility, the solution becomes supersaturated and gypsum crystallizes out.

Grimsley's theory. Grimsley[1] noted that, " when water is added to the calcined plaster, small needle-like prisms are seen forming and shooting out here and there. As these become more and more abundant, they unite with one another and rapidly form a solid mass, in which the individual crystals can scarcely be distinguished. Open spaces are left in the mass apparently filled with water, and finally these are closed, and a firm solid mass results."

He also noted that crystallization was more rapid in the finer grained plasters than in the coarser ones. He agrees with the investigators mentioned above that the setting of plaster is due to the formation of a crystalline net-work, but his explanation of the cause of the formation of this net-work is somewhat different, and a summary of the same is given below.

1 When water is added to plaster of paris, the plaster becomes partially dissolved.

2 When the solution becomes hydrated and supersaturated crystallization is started, and the liquid becomes turbid.

In explanation of this theory, Grimsley says:

> The solution of the hydrate in these experiments is certainly saturated, and all that is needed is something to start the crystallization. From a study of saturated solutions in the laboratory, it is well known that if crystals are introduced into such solutions, crystallization will result and go on until the salt has crystallized out.
>
> The effect of heat on gypsum in the burning of plaster is to remove a certain percentage of water, and to break up the small masses of the rock into finer and finer particles, microscopic and even ultra-microscopic in size. If the heat has not been carried too far, certain particles through the mass may still possess their crystalline form, and so they are true crystals, though very small. These minute crystals in the saturated solution

---

[1] Grimsley, G. P. & Bailey, E. H. S. Special Report on Gypsum and Gypsum Cement Plasters. Univ. Geol. Sur. of Kan. Topeka 1899. p. 92–96.

would start the process of crystallization. Their growth would cause the turbidity of the solution noted by Marignac, and would result in a precipitation of small gypsum crystals, thus forming a crystal net-work which constitutes the set of plaster.

If the plaster is underburned the gypsum is not reduced to its proper fineness and uniformity, and so would not permit the crystallization to go on in the way it would in the properly burned plaster. But of more importance the hydrate represented by plaster of paris would not be formed.

If the plaster is overburned, the plaster will be so completely comminuted that no minute crystals will be left to start the crystallization. Where the plaster is slightly overburned, the crystals are extremely fine and crystallization goes on very slowly and imperfectly.

Retarders. The question of retarding the set of plaster of paris is one that has received a great deal of attention in the past few years, and the substances which are used are almost too numerous to mention. The principal materials used are different forms of organic matter, as glue, starch and animal refuse. These when moistened form a gelatinous liquid, which hinders the formation of the crystals.

The carbonates of the alkaline earths are sometimes used to dilute the plaster. Slaked lime or calcium hydrate is used to make a lime plaster putty, which sets quite slowly and is used largely in the manufacture of relief forms for ornamentation.

As a usual thing, the addition of any material which is not a stronger cementing material than the plaster of paris will have a tendency to render the hardened plaster weaker than it would be in the pure state. It is possible, however, that even the addition of material that may be considered a diluent may give hardened plaster that will be fully as strong as the pure material would be, if not stronger. Experiments have not been made with a view of ascertaining the truth of this, but the ultimate strength of the hardened plaster seems to be due to the filling of all crevices in the material and the addition of a material which helps to fill the crevices should have this effect.

It is known that in the manufacture of Portland cement, equal portions of cement and sand can be ground together, and the resulting mixture when moistened gives better results in tensile strength than pure Portland cement.[1] This is due to the fact that the particles of sand afford surfaces to which the cement may adhere.

The retarders used by most of the plaster manufacturers consist of a mixture of various materials, and some of the mixtures appear almost ridiculous. The essential constituents however are certain forms of organic matter, among which are included glue, glycerin, sawdust, sugar, oils, paper pulp, flour pack, fiber, oil meal, molasses, Irish moss and tankage. The inorganic materials consist largely of different salts of the alkalis and alkaline earths, acids and other forms of cement.

The ultimate strength of a retarded plaster will depend largely on the changes that will take place in the material used to retard the set. Many of the organic materials mentioned above would undoubtedly decompose to a certain extent. If present only in small quantities, their effect on the strength of the plaster would probably be very slight, but the presence of any material which is likely to decay is of no advantage to the plaster, not only from a consideration of strength but also from a sanitary standpoint. Great care should therefore be taken in the selection of an organic retarder.

The addition of a good mineral retarder, however, is likely to prove an advantage, as the fact that the set is retarded gives strength to the supposition that the resulting network of small crystals will be much stronger because of the length of time required for the set. It has been shown [p. 125] that, in the manufacture of Portland cement, the addition of gypsum in quantities not over 2% of the whole, increases not only the time required for setting but the ultimate strength of the cement.

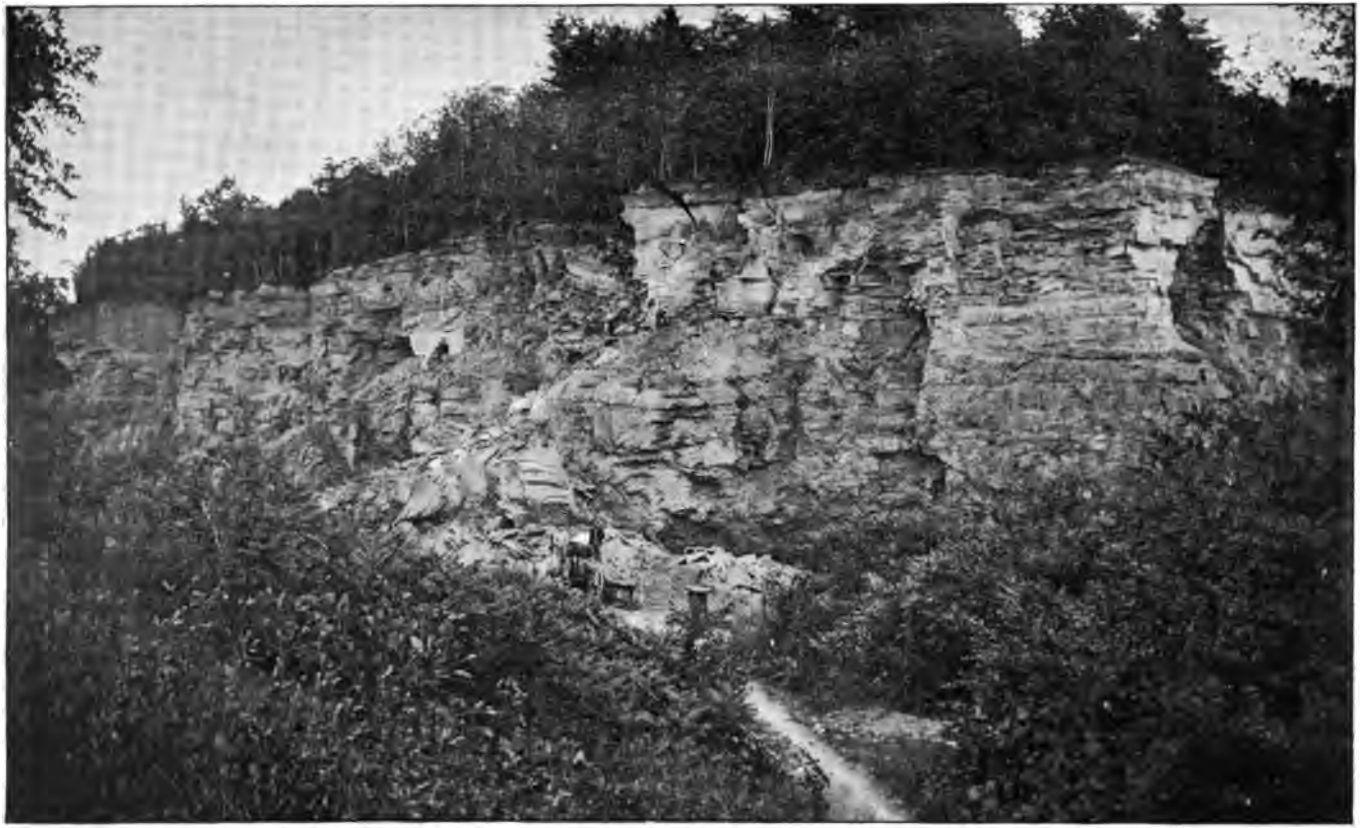
It has also been shown[2] that there is apparently a definite relation between the length of time required for setting and the tensile strength, and up to a certain point those cements which

---

[1] Newberry, S. P. Eng. News, Ap. 16, 1896. p. 252.

[2] Ries & Eckel. Lime and Cement Industries of New York, pl. 91 to 98 inclusive.

Plate 1



Gypsum quarry of F. M. Severance, Fayetteville N. Y.

require the longest time for setting show the greatest strength. This seems to give some ground for the supposition that retarding the set does not decrease the strength. It also shows that a material which of itself may not be as strong as the material whose set is to be retarded, may give increased strength to the retarded material.

Accelerators. It is sometimes necessary to hasten rather than retard the set of plaster, and in order to do so, some other crystallizing salt as alum or borax is added in small quantity to the plaster. When moistened, this salt has a tendency to crystallize and starts that process in the plaster of paris. A dish which has been used in making plaster of paris will have a tendency to accelerate the set because of the crystals already formed.

New York mines and mills

Cottons. At Cottons an open quarry is worked by Mr R. D. Button. Ordinary black powder is used as the explosive, and the entire output is used in the manufacture of land plaster. An analysis[1] of the rock follows:

Sulfate of lime (pure gypsum)	82.66
Carbonate of lime	6.569
Carbonate of magnesia	5.075
Iron oxid and alumina	1.837
Insoluble matter and moisture	3.859
	100

The greater part of the rock is ground at Perryville by Mrs Hattie C. Hodge.

Fayetteville. The quarries at Fayetteville are located about 2 miles southwest of the village and are situated on two knolls.

Four companies have quarries here: the National Wall Plaster Co. and the Adamant Wall Plaster Co. of Syracuse, Mr F. M. Severance and Mr C. A. Snooks of Fayetteville.

All these quarries were at one time owned by the Onondaga Gypsum Co., which was formed in 1878 and operated as a plaster trust. After three years the company was dissolved, and the property went into other hands.

---

[1] Analysis furnished by R. D. Button.

The oldest quarry is that of Mr Severance, which has been worked since 1812. The bed of gypsum in this quarry is about 60 feet thick and consists of eight layers varying in thickness from 18 inches to 30 feet. It is covered with about 40 feet of shaly rock, together with hydraulic limestone.

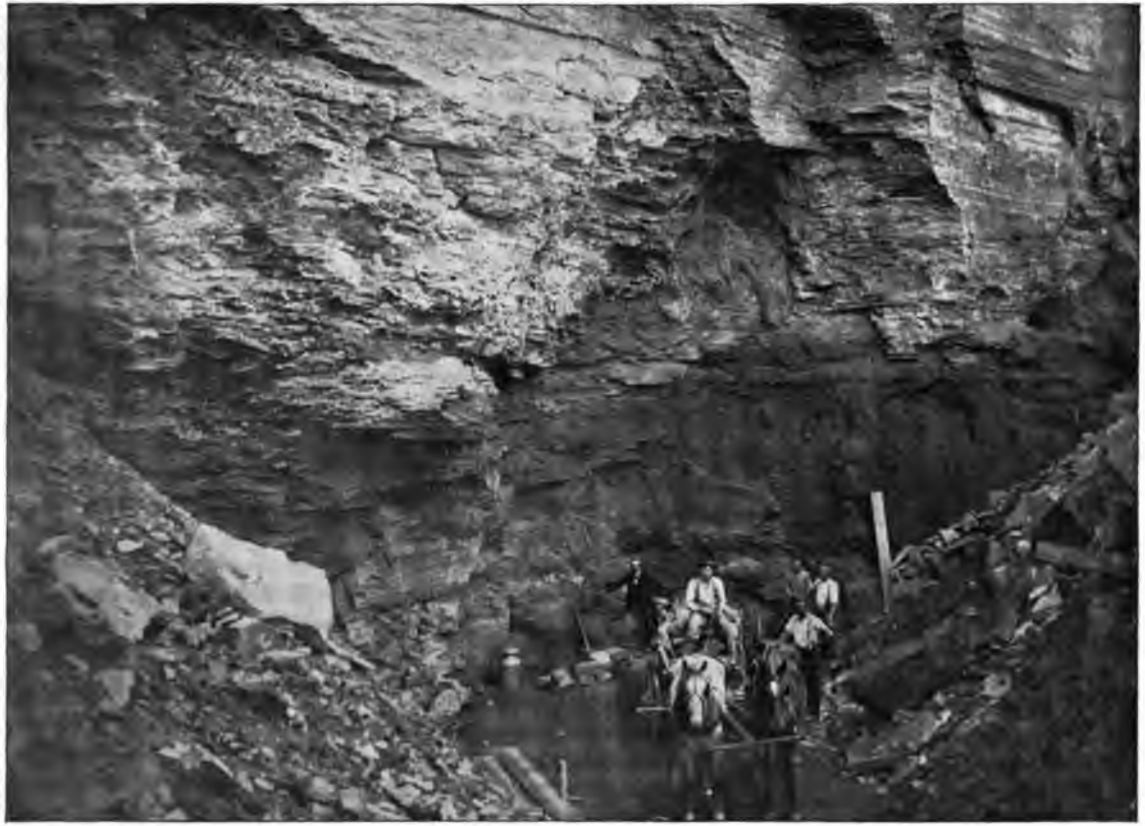
The plaster rock varies in color from light drab in the cap to a dark brown (iron layer), all forms becoming lighter on exposure to air. The so called "slate" consists of fibrous, scaly, and other forms of gypsum; the remaining beds consist almost entirely of compact gypsum.

The specific gravity varies from 2.68 in the 9 foot layer to 2.33 in the slaty layer.

The composition is nearly uniform, consisting of gypsum from 80% to 90%; calcium carbonate, a trace; magnesium carbonate, 5% or less; clay, 10% or less. The amount of carbonates is greatest in the iron layer, showing effervescence in the mass. It is nearly as abundant in the cap layer; it is least in the crystalline layer (the so called *slate*); but in none of the layers is the quantity sufficient to prove detrimental. To quarry this gypsum, the slate rock above must be stripped. This stripping is accomplished after a portion of the quarry has been worked out, by blasting out a layer of shale about 4 feet in thickness immediately above the plaster rock. When sufficient has been blasted, the overlying *slate* falls down into the hole from which the gypsum has been removed, and the new part exposed can be quarried without removing very much of the strippings. Mr Severance claims that in this way he has to remove only about one third of the stripped rock.

When quarrying the gypsum, three beds are recognized by the quarrymen. The upper bed is the lightest of the three and is about 30 feet thick. The lower beds are of darker color, showing more marked strata of light and dark gypsum, and are said to be richer in sulfate of lime.

Plate 2



Gypsum quarry of F. M. Severance, Fayetteville N. Y.

The local mills are furnished with gypsum rock in the winter time, and the outsiders during canal navigation. The rock has to be hauled about 1½ miles to the canal. The quarry is operated the year round. The cost of mining is about 25c to 30c a ton, and the rock sells, delivered at the canal or to the local mills, for 90c a ton. From four to 12 men are employed at the quarry, according to the demand for gypsum.

Immediately adjoining Mr Severance's quarry are the quarries of the National Wall Plaster Co., which are in the same deposit as the foregoing. The method of quarrying, however, differs in some respects. The gypsum is quarried so as to cut under the overhanging rock, which then falls into the place from which the gypsum has been taken. This necessitates moving a greater amount of rock than the method employed by Mr Severance. In these quarries dynamite and Climax blasting powder are used. From 12 to 20 men are employed at the quarries. In the strippings some hydraulic limestone is found, which is sold to cement manufacturers.

The beds owned by the National Wall Plaster Co. occupy about 5 acres. At this company's mill, which is located on the bank of the canal, about 1½ miles from the quarry, the Cummer process of calcining the gypsum is employed. About a year ago two kettles made by Butterworth & Lowe were set up in this mill. The equipment of the mill consists of one Blake crusher, one calciner, one cooling bin, two kettles, two Sturtevant emery mills. The capacity of the mill is seventy-five tons a day. The product is used in wall plaster but a large portion of it is sold to Portland cement manufacturers. A large part of the product that goes to the Portland cement manufacturers is not ground after passing through the calciner, but is shipped as it comes from the kiln and is mixed and ground with the cement.

On the east of the National Wall Plaster Co.'s beds and south of those owned by Mr Severance is located the property of the Adamant Wall Plaster Co. This company owns about 19 acres of ground, about 15 of which are underlain by gypsum. This property is not worked at present, and the company is using calcined plaster from Oakfield N. Y.

The quarries of Mr C. A. Snooks occupy about 3 acres. The beds are about the same as those on the adjoining hill. The product is used by local mills entirely.

Jamesville. In the quarry of E. B. Alvord & Co., of Jamesville, the rock is quarried by the use of hand drills. The explosive used is black powder. The mill has a capacity of about 25 tons in 10 hours. The equipment consists of a cracker and burstone mill. The power is furnished by a 70 horse power turbine. This mill has been run by the present owners since 1869, but the date when gypsum was first dug at this place was much earlier. The entire product of the quarry is used for land plaster.

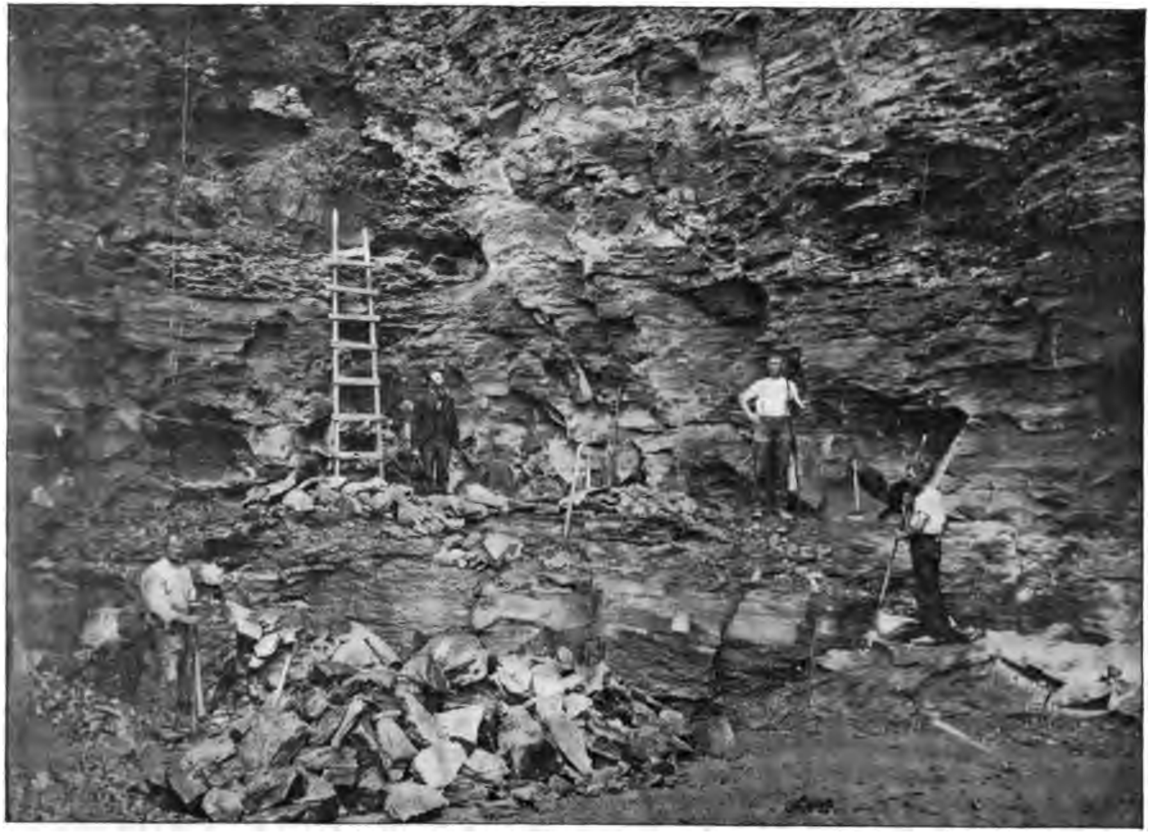
Marcellus. Near the station a small quarry is worked by Mr Walker. The product is used entirely in the immediate locality. The annual output does not exceed 500 tons.

In grading for a trolley line from Marcellus station to the village an outcrop of plaster rock was exposed in 1900 near the station. The outcrop is about 20 feet thick and extends along the road about 160 feet. The rock shows layers of white fibrous gypsum at intervals ranging from 3 to 12 inches. These layers are from ¼ inch to 1 inch in thickness. The main rock does not seem so solid as the material found at Union Springs and Fayetteville, but should make a fair land plaster. The bed seems to be quite extensive, judging from the fact that it is found at the same horizon just across the valley. Outcrops of the same bed are to be seen between Marcellus Station and Fairmount in the hill at the south of the railroad, and it is said that many thousand tons of this material were taken out when the New York Central Railroad was being put through.

Syracuse. Two and one half miles south of Syracuse gypsum was formerly quarried by A. E. Alvord, but the bed became exhausted, and no work has been done since 1901.

Phelps. Mr A. D. Miller has for many years operated a quarry at this place; his only product is land plaster. The quarry is on

Plate 3



Gypsum quarry of F. M. Severance, Fayetteville N. Y.

Canandaigua outlet and is well exposed; so the quarrying operations are easy.

Victor. A quarry and mill for the manufacture of land plaster are owned at this point by Mr Theodore Conover.

Port Gibson. At Port Gibson are the quarry and mill of Mr Ezra Grinnell. The rock is well exposed in the bed of the stream at this place, and, the water having been diverted for mill purposes, the bed of the stream is left dry, so that it is easy to quarry the gypsum. For several years the work at this place has been intermittent, and at present only a local trade is supplied with land plaster.

Union Springs. The first mining of gypsum at Union Springs was probably commenced while the Erie canal was being built. As early as 1822, Robinson, in his catalogue of localities of American minerals, states that several thousand tons of gypsum were shipped annually from this point to Pennsylvania.

At present the only quarry of importance at this location is that of the Cayuga Land Plaster Co. The plant is about a mile or a mile and one half north of Union Springs, on the line of the Lehigh Valley Railroad, near the junction of the Cayuga branch and the Auburn branch. The quarry is about an eighth of a mile from the mill, and the material is hauled in carts to large drying sheds adjoining the mill. The stripping at this quarry varies from 2 or 3 to 20 or 25 feet of earth, there being very little rock overlying the gypsum, though in one or two places a few feet of waterlime have been observed. The dirt is stripped and carried to the dump, though a few years ago the stripping was much simplified by the Lehigh Valley Railroad Co., which ran a switch to the quarry and took this overburden of earth for filling along its line.

Power drills have not been introduced at this quarry, but the old jumper drill still holds its own. The explosive used is black powder. The mill equipment of this company consists of one Blake crusher, one cracker or nipper, and five burstone mills.

An analysis of the plaster made for this company shows

Sulfate of lime	80.78
Carbonate of lime	1.76
" magnesium	3
Phosphate of lime	.43
Sand	3.32
Organic matter	.18
Chlorin, potash and clay	10.05
Total	99.52

The general color of the gypsum rock when first quarried is a dark gray, but on exposure to the air, it becomes very much lighter. Occasionally plates of selenite intermingled with impure rock are found, and at times well formed crystals and large plates of selenite are encountered.

In this vicinity are several old quarries which are not worked at the present time.

Garbutts. At Garbutts are located the mines and mill of the Lycoming Calcining Co., which began operations at this place in 1900. Before that time a mine was operated by Mr John Garbutt for many years, and the output was disposed of entirely in the form of land plaster. The old mine was reached by a shaft; but, with the beginning of work by the new company, a tunnel was driven into the gypsum from the bank of Allen's creek, and the creek was bridged so that the cars could be hauled directly from the mine to the mill. There are three deposits of gypsum with intervals of about 6 feet between them. Two mines have been opened into the upper deposit, and recently a tunnel has been driven into the second bed. The waste rock is carefully corded up in the mine in such a way as to help sustain the roof, so that a larger proportion of the gypsum can be removed than could otherwise be taken out. The quality of the gypsum is the same as that of the Wheatland rock, and little difference can be detected between this rock and the product of the mines at Oakfield and Indian Falls.

In calcining the gypsum the Cummer process is used, and the equipment of the mill consists of a Butterworth & Lowe crusher, one calciner, four coolers and four Sturtevant emery mills. Difficulty was experienced at first in securing a satisfactory product, but certain modifications have been brought about in the process, so that a ready market is secured for the entire product. The Diamond Wall Cement Co. uses a large proportion of the product in the manufacture of cement wall plaster, and recently (December 1902) the Sackett Wall Board Co. has commenced the manufacture of its patent wall board in a large building near by, in which it uses about 150 tons of stucco each week.

Wheatland. About 3½ miles east of Caledonia are located the mines and mills of the Wheatland Land Plaster Co. The mine is located in a knoll and is entered by a tunnel. The gypsum deposit is about 6 feet thick and consists of three distinct layers, the best being in the middle. The drills used are hand power, Howell twist drills, and the explosive is dynamite. In taking out the gypsum, pillars are left which range in size from 15 feet in diameter to 30 x 75 feet according to the condition of the roof.

Timbers are used in all parts of the mine. The rock is hauled from the mine on cars holding about a ton. The floor of the mine is about on a level with the mill, which is on the opposite side of Allen's creek, so that the cars can be hauled directly from the mine to the mill. The mills consist of two buildings. In the nearest one to the mine are a Blake crusher and two burstone mills. In the other building, which is much larger, are a nipper and two burstone mills.

When the rock is brought from the mine, the cars are halted at the first building and the larger pieces thrown into the crusher, in which the rock is reduced to about three quarters of an inch in diameter. The smaller pieces of rock are then taken to the second mill and run through the nipper. Most of the plaster from these mills is shipped in bulk in carload lots. Some of it, however, is used in the manufacture of an insecticide.

A second deposit has recently been opened up, about 6 feet below the first, which is said to show over 90% gypsum.

Oakfield. Two companies, the United States Gypsum Co. and the Oakfield Plaster Manufacturing Co., are engaged in mining and calcining gypsum at Oakfield.

The United States Gypsum Co. is the larger of the two and operates the mines and mills formerly worked by the English Plaster Co. and the Genesee Plaster Co. This company was formed in the winter of 1901-2 and controls factories in Michigan, Iowa, Kansas and Oklahoma as well as New York. In addition to the plants mentioned above, the Buffalo Mortar Works and the Big Four Wall Plaster Co. were taken into the combine.

For many years Mr Olmsted mined gypsum and manufactured land plaster at Oakfield, and about 1892 he put in one kettle to make plaster of paris. So far as is known, this was the first attempt to calcine New York gypsum on a large scale, and it was successful from the outset. Subsequently the property was purchased by the English Plaster Co., and a new plant was erected. The equipment of this mill consists of one Blake crusher, one nipper, five kettles and five burstone mills. Two mines supply the rock for this mill. These mines are about 40 feet deep, and the rock is hoisted by steam power. The bed of gypsum is only about 4 feet thick, but it is said that about 80 feet below this deposit is another bed about 10 feet thick, but this has not been developed, nor is anything known concerning its quality.

Water gives a great deal of trouble in the mines, and one of them has to be abandoned in the winter because of the difficulty and expense of pumping the water. Howell twist drills are used to make ready for the blasts, and black powder is the explosive used.

The mill formerly owned by the Genesee Plaster Co. is the most convenient one in the State using the kettle process. To the regular calcining equipment has been added the machinery of the Big Four Plaster Co., which was formerly located in the village, so that the entire equipment consists of one Blake crusher, one nipper, eight burstone mills, four kettles, two shaking screens, one single mixer, one triple mixer and one sand drier. The power for running the machinery is furnished by a 250 horse power cross compound engine.

At the west end of the mill is a large rock shed, where in slack times the surplus rock is stored. When the mill is running to its full capacity, it takes the full output of the mine to keep it running. The plaster rock for this mill is obtained from two mines about a half a mile north of the mill. They are entered by a vertical shaft, and the rock is raised from the mines by two 50 horse power hoisting engines. Howell twist drills, run by compressed air, are used, and an automatic air compressor at each mine furnishes the requisite power. The blasting is all done with black powder. At the east end of the mill is the sand bed where the sand for the *Big Four wall plaster* is stored and dried. This sand is brought from the pit, which is about a quarter of a mile northeast of the mill, by a tramway, and after it has been dried and screened, it is put in a storage bin, from which it is taken, as required, to the mixers. As noted in the statement of the equipment, there are two mixers, one single and the other triple. The first of these is used in mixing the hard wall plaster which is sold under the name of *Ivory wall plaster*, while the triple mixer is used in the mixing of the sand and fiber plaster known to the trade as the *Big Four wall plaster*.

On the third floor of the mill is a testing laboratory for testing the strength of the plaster. Samples of every shipment are tested, and the record, as well as a duplicate sample of the material, is kept, so that the company is able not only to know that satisfactory material is being shipped, but, in case of complaint, to prove the quality of the material when shipped. The results of the tests for tensile strength made in the laboratory are possibly somewhat lower than they should be, because there is a great deal of vibration in this part of the mill, which has a tendency to cause the briquets to break sooner than they otherwise would.

Average results for one day range from 150 to 170 pounds
" 20 days " 250 to 280 "
" 30 " " 340 to 410 "

A test of samples sent from this mill was made by the city surveyor of Utica N. Y., with the following results.

1 day .... 93 pounds
2 days .... 210 "
5 " .... 300 "

At present no plaster is calcined in the English mill on account of the superiority of the arrangement of the new mill, but this mill is used entirely in grinding land plaster and the kettles are kept ready only for emergencies.

The mill of the Oakfield Plaster Manufacturing Co. is about 2½ miles west of Oakfield, adjacent to the West Shore Railroad tracks. The equipment consists of one Blake crusher, two burstone mills, two kettles and one bolting cloth. A large rock shed in which surplus rock may be stored is on the north side of the mill just outside the crusher room.

The various stages in the manufacture are the same as in other kettle mills, but bolters are still used instead of the more economical shaking screens. Above the kettles in the steam flue are two dust chambers to collect the fine plaster which is driven off in the cooking.

The mines of this company, three in number, have vertical shafts, and the rock is hoisted by horse power. The rock is hauled to the mill in wagons. Much trouble is experienced in these mines on account of water, which is more troublesome in the winter than in summer, so that almost all the mining must be done in the summer, because of the impossibility of getting rid of the water except with powerful steam pumps. On the occasion of the author's visit the mill was closed.

Indian Falls. About a mile and a half from the village of Indian Falls on the Tonawanda Indian reservation are the mines of the Standard Plaster Co. of Buffalo. A railroad has been built by the company from the mines to the West Shore Railroad a little west of Alabama, and the rock is shipped to the company's mill at Black Rock.

About 6 feet of good gypsum are mined, while overlying this are about 8 feet of an impure gypsum, which is too hard for use.[1] Above this upper bed of gypsum is a crumpled deposit of impure limestone, which is much broken up. The gypsum rock is found outcropping along the creek for more than half a mile and is about 30 feet above the creek, so that it is mined by tunnels, and the rock is loaded directly from the mine cars onto the railroad cars for shipment. Intermittent mining has been carried on at this place for years, but no work of any importance was undertaken till the summer of 1901, when the Standard Plaster Co. secured the mining right for the entire reservation and opened its first tunnel.

The only great difficulty encountered in mining the gypsum is caused by the mud pockets described in a former chapter [p. 110]; but this difficulty is likely to grow less as the overburden becomes greater, and the chance of surface water reaching the deposit becomes less. Howell's twist drills are used in drilling the rock, and both hand and power drills are employed. The power is furnished by an automatic air compresser for the air drills, and black powder is used in blasting. The rock is loaded on small flat cars, holding about a quarter of a ton, which are pushed to the entrance of the mine, where the rock is sorted, the good rock being thrown into the railroad car and the waste being thrown over the bank of the creek.

The mill of this company is located on Dart street and Scajaquada creek, Black Rock. The equipment consists of a gyratory crusher and screen, one Cummer calciner, one cooling bin and five Sturtevant emery mills.

The power is furnished by two electric motors of 100 horse power and 250 horse power respectively, which are run by electricity brought from Niagara Falls. In order to prevent the escape of dust from the calciner, a stream of water is sprayed on the smoke and dust at the top of the flue, which is turned downward, and as a consequence the coat of plaster of paris, which is so common around other plaster mills, is entirely lacking here.

---

[1] It is probable that this upper layer is anhydrite as after this report was prepared the deposit in the Lehigh shaft at Leroy which was supposed to be gypsum was reported by Mr Charles Root of Caledonia to be anhydrite. The greater hardness and the higher percentage of $CaSO_4$ would indicate this mineral.

For some time hollow fireproofing blocks similar to the hollow brick used for partitions in fireproof buildings, were made here, but the demand for stucco has been so great that this branch of the industry has been temporarily discontinued.

Akron. At Akron a shaft has been sunk, and it is expected that gypsum will be mined shortly. Up to the present time, however, nothing has been done.

Production of gypsum in New York

The production of gypsum for New York since 1889, was as follows:

Year	Product		Value
1889	52608	short tons	$79476
1890	32903	"	73093
1891	30135	"	58571
1892	32394	"	61100
1893	36126	"	65392
1894	31798	"	60262
1895	33587	"	59321
1896	23325	"	32892
1897	33440	"	78684
1898	31655	"	81969
1899	52149	"	105533
1900	58890	"	150588
1901	119565	"	241669
1902	110364	"	259170
1903	137886	"	462383

ANALYSES OF GYPSUM

The following table of analyses of gypsum is compiled to show the comparative merits of the great deposits of this country. It has been somewhat difficult to obtain satisfactory analyses of New York State gypsum, as few samples have been analyzed except for manufacturers, and in many cases the writer is compelled to admit that little dependence can be placed on analyses made for the sale of materials. A comparison of the circulars sent out by different firms several years ago, shows the material advertised as containing from 80% to 90% of pure gypsum, while the material sold by competitors is represented as containing from 60% to 80%. It is safe to say, however, that the average product from the principal working deposits will run from 70% to 75% gypsum.

	1	2	3	4	5	6	7	8	9
Gypsum	82.89	81.5				94.84	94.56	87.81	96.46
SiO_2 and insol	4.3	5.3	2.8	.15	6.43	1.88	2.67	.99	2.57
Other matter						4.28	2.77	11.2	.97
CaO			31.87	32.44	29.41				
MgO									
K_2O									
CO_2									
SO_3			45.76	46.61	44.19				
H_2O			19.9	20.74	20.18				
Al_2O_3	8	2.41	.6		.64				
Fe_2O_3	.21	.25							
$CaCO_3$	9.8	9.47							
$MgCO_3$	.79	.59							
$CaSO_4$									
	100.99	99.52	100.98	99.94	100.85	100	100	100	100

	10	11	12	13	14	15	16	17	18	19	20
Gypsum	74.09	64.53	73.92	82.5	82.66		78.44		70.73	94.03	
SiO_2 and insol	6.05	11.17	4.64		3.859	.91	.65				
Other matter	19.86	24.27	21.44	12.15						5.97	
CaO						32.85		32.88			
MgO						.54					
CO_2											
SO_3						46.38		45.79			
H_2O						19.7	20.76	20.98			
Al_2O_3					} 1.837	.6					
Fe_2O_3											
$CaCO_3$				1.75	6.569						
$MgCO_3$				3.6	5.075						
$CaSO_4$											
					100	100.48	99.85	99.65			

	21	22	23	24	25	26	27	28	29	30	31	32	33
Gypsum	88.8	88.9	83.2	72	87	72.6	......	......	......	......	......	......	......
SiO_2 and insol	2.2	1.4	4.8	14.3	13	6	.35	.65	.4	.35	1.18	.52	.19
Other matter	......	......	......	9.8	......	......	......	......	......	......	......	......	......
CaO	......	......	......	......	......	......	32.44	33.51	32.28	......	......	32.28	32.53
MgO	......	......	......	......	......	......	.12	.19	.17	......	......	.98	.16
CO_2	......	......	......	......	......	......	......	......	......	......	......	1.90	.81
SO_3	......	......	......	......	......	......	46.24	46.65	45.96	......	......	44.61	45.73
H_2O	......	......	......	......	......	......	20.52	18.84	20.36	19.96	20	19.47	20.46
Al_2O_3	......	......	......	......	......	......	} .12	.17	.19	.12	.15	.26	.1
Fe_2O_3	......	......	......	......	......	......							
$CaCO_3$	9	9.7	12	8.9	......	22	......	......	......	.56	.36	......	......
$MgCO_3$	......	......	......	......	......	......	......	......	......	.57	.52	......	......
$CaSO_4$	......	......	......	......	......	......	......	......	......	78.4	78.04	......	......
										99.96	100.25	100.02	99.98

	34	35	36	37	38	39
Gypsum						
SiO_2 and insol.	.55	10.67	12.13	8.78	2.17	2.9
Other matter						
CaO	32.64	30.2	29.14		32.42	
MgO	.22	.51	.42		.45	
CO_2	.63	5.08	2.03		1.67	Mg SO_4 .61
SO_3	45.95	34.98	37.49		44.18	
H_2O	19.54	16.59	16.75	20.66	19.4	20.2
Al_2O_3 } Fe_2O_3	.23	.6	.99	1.98	.24	.6
$CaCO_3$				7.25		
$MgCO_3$				1.12		
$CaSO_4$				58.25		75.66
	99.76	98.63	98.95	98.04	100.53	

1 Pyramid of Cheops, exterior. Thorpe. Dictionary of Applied Chemistry. 1:468

2 Pyramid of Cheops, interior. Thorpe. Dictionary of Applied Chemistry. 1:468

3 Wienrode. Analyst, Jungst

4 Osterode. " Hampe

5 Albay, Philippines. " Trobe

6 Nova Scotia. Rep't Ct. Agric. Exp. Sta. 1883

7 " " "

8 " " "

9 " " "

10 Union Springs N. Y. " 1884

11 Fayetteville N. Y. Rep't Ct. Agric. Exp. Sta. 1883

12 " " "

13 Wheatland N. Y.

14 Cottons N. Y.

15 Ottawa county, O. Geol. of Ohio. 1888. 6:696-702

16 Fort Dodge Ia. Geol. Sur. Ia. 3:291

17 ——— Mich. Analyst, George H. Ellis, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 143

18 Wheatland N. Y. Anal. furnished by Iroquois Portland Cement Co.

19 " 2d bed. Anal. furnished by Consolidated Wheatland Plaster Co.

20 ....

21 Coalinga Cal. Univ. of Cal. Exp. Sta. 1891-92

22 Nevada Gypsum and Fertilizing Co. Univ. of Cal. Exp. Sta. 1891-92

23 Bakersfield mine, Cal. Univ. of Cal. Exp. Sta. 1891-92

24 Southern California " "

25 San Francisco Cal. " "

26 Los Angeles Cal. " "

27 Fowler mine, Blue Rapids Kan. Analyst, Edward Bartow, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 145

28 Great Western, Blue Rapids Kan. Analyst, Edward Bartow, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 145

29 Winter's mine, Blue Rapids Kan. Analyst, Edward Bartow, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 145

30 Dillon Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 146

31 Four miles south of Dillon Kan. Analysts, Bailey & Franklin, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 146

32 Hope Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 147

33 Medicine Lodge Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 147

34 Solomon Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 148

35 Marlow, I. T. Analysts, Bailey & Stafford, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 149

36 Dillon Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 149

37 Rhoades Kan. Analysts, Paul Wilkinson, Univ. Geol. Sur. Kan. v. 5. Gypsum, p. 150

38 Mulvane Kan. Analysts, Bailey & McFarland, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 155

39 Lake Tank, New South Wales. Liversidge, A. Minerals of New South Wales, p. 164

LIST OF FIRMS AND INDIVIDUALS THAT MINE AND MANUFACTURE NEW YORK GYPSUM

Clockville, J. A. Mason jr.

Cottons, R. D. Buttons

Fayetteville, C. A. Snook, National Plaster Co., office at Syracuse, F. M. Severance

Garbutts, Lycoming Calcining Co.

Hobokenville, Irving Tuttle

Indian Falls, Standard Plaster Co.

Jamesville, Robert Dunlop, Simon Reals, E. B. Alvord & Co.

Manlius, James Behan *Est.*

Oakfield, Oakfield Plaster Manufacturing Co., U. S. Gypsum Co.

Perryville, Cyrus Worlock, Mrs Hattie C. Hodge

Phelps, A. D. Miller

Port Gibson, Ezra Grinnell

Union Springs, Cayuga Plaster Co.

Valley Mills, W. H. Osborne & Co.

Victor, Theodore Conover

Wheatland, Wheatland Land Plaster Co.

It was the intention, when this publication was started, to include a description of the mills calcining and using foreign gypsum. This, however, has been found to be impracticable, but a list of those who use this material is appended.

LIST OF MANUFACTURERS IN NEW YORK STATE WHO USE GYPSUM FROM OUTSIDE OF THIS STATE

Adamant Plaster Co.	Syracuse and New York city
American Hard Wall Plaster Co.	Utica
Higginson Mfg. Co.	Newburg
J. B. King & Co.	New York city
V. C. & C. B. King	New York city
Paragon Plaster Co.	Buffalo and Syracuse
Rock Plaster Co.	New York city
Schenectady Wall Plaster Co.	Schenectady

BIBLIOGRAPHY

The following is a list of some of the most important articles treating on gypsum in general and New York gypsum in particular. The list might be greatly extended so as to embrace those describing other localities, but it is believed that the reader will find every important phase of the technology and manufacture of gypsum taken up by the authors noted below.

Solubility of gypsum

Hulett, George A. and Allen, Lucius E. The Solubility of Gypsum. Jour. Am. Chem. Soc. July 1902. No. 7, v. 24

McCaleb. Am. Chem. Jour. 1889. 2:30

Marignac. Annales de chimie. Ser. 5. 1:274

Rose, H. Poggendorff Annalen. 93:606

Storer. Dictionary of Solubilities

New York gypsum deposits

Clarke, William C. Gypsum Industry of New York State. New York State Mus. Bul. 11. 1893. p. 70–84

Merrill, F. J. H. Gypsum Deposits of New York. New York State Mus. Bul. 15. 1895

Parsons, Arthur L. Recent Developments in the Gypsum Industry of New York State. 20th Rep't State Geologist. Alb. 1900

Williams, S. G. Geological Relations of the Gypsum Deposits in Cayuga County, N. Y. Am. Jour. Sci. September 1885. v. 130

Technology of gypsum

Grimsley, G. P. Technology of Gypsum. Mineral Industry, v. 7

Grimsley, G. P. and Bailey, E. H. S. Special Report on Gypsum and Gypsum Cement Plasters of Kansas. Univ. Geol. Sur. Kan. Topeka 1899

Knapp, F. Chemical Technology. Am. ed. Phil. 1849. 2:400–12

Le Chatelier, Louis. On the Dehydration of Gypsum Stone and the Two Compounds Formed. Académie des sciences. Comptes rendus. 1883

Payen. Traité du chimie industrielle. 1830

Redgrave. Calcareous Cements, their Nature and Uses. 1895

Thorpe. A Dictionary of Applied Chemistry, article on cements. v. 1

Wagner, Rudolph. Chemische Technologie

Wilkinson, Paul. Technology of Cement Plaster. Am. Inst. Min. Eng. Trans. July 1897

Origin of gypsum

Dieulafait. Produits, successifs, abandonnés par les eaux de la mer. Annales de chimie. Ser. 5. 1878. 14:381

Hunt, T. Sterry. Origin of Gypsum, Chemical and Geological Essays, ch. 8

———. Origin of the Gypsum of Plaister Cove. Quar. Jour. Geol. Soc. 5:339

Ochsenius. On Composition of Sea Water. Chem. Zeitung. 1887. v. 2, no. 56, *et seq.*

Gypsum as fertilizer

Davy, *Sir* **H.** Agricultural Chemistry

Johnson, C. W. An account of Gypsum as a Manure to the Artificial Grasses. Royal Agric. Soc. England. Proc. 1841. v. 2

Liebig. Chemistry of Agriculture

Stockhardt. A Familiar Exposition of the Chemistry of Agriculture. 1855

Storer. Chemistry of Agriculture. 1887. 1:206, 216

ABRASIVES OF NEW YORK STATE

BY HARRY C. MAGNUS

In the following paper the writer has endeavored to present in collected form the substance of all published matter which has for its subject any of the various abrasive materials found within the limits of New York State. A large amount of material has been obtained from previous publications of the State Museum. The *American Journal of Science and Arts, the Scientific American, Mineral Industry, Transactions of the American Institute of Mining Engineers* and other scientific and technical publications have also been fruitful sources of reference. Information concerning the development of the several industries within recent years has been furnished to the writer by the individuals and companies engaged in the mining and preparation of the various materials; and to these, notably, Herman Behr & Co., Mr F. C. Hooper of North Creek, Warren co., H. H. Barton & Sons Co., the Norton Emery Wheel Co., the Standard Emery Wheel Co., the Pike Manufacturing Co., Mr J. S. Van Etten and the Carborundum Co., he wishes to express his indebtedness for much valuable assistance.

A list of references on the abrasive materials of New York is appended to this paper under the title of Bibliography.

Garnet

Garnet, though one of the most abundant rock-forming minerals, is found in only a few localities of proper character to be of value as an abrasive. It is mined or quarried in New York State on the southeastern border of the Adirondack region, in Warren and Essex counties, where it appears to be of the common variety, "almandite." In Delaware county, Pa., it occurs near Chelsea in small crystals thickly disseminated through a quartzose gneiss. This deposit about the year 1895 yielded 1000 tons annually.[1] There is also a deposit of garnet near Chester Pa. In North Carolina large deposits of garnet were worked in connection with the deposits of corundum. These yielded the first American garnet, but were abandoned as of inferior quality when the New York State material appeared in the market. Other deposits are said to occur in Georgia and Alaska, but no definite information can be obtained about them. Maine has supplied a very limited amount of inferior material, and Connecticut for a time competed in the production of garnet for sandpaper used in the shoe trade. In 1898 Connecticut together with Pennsylvania furnished 1200 tons of garnet, but New York garnet has gained great favor in the market owing to its superior hardness.[2]

In New York, garnet is found, in Warren county, in the valley of the upper Hudson river and in Essex county on the borders of the Adirondack region. These deposits were described by Mr Verplanck Colvin in his report on the New York State Land Survey for 1896 as follows:[3]

> Garnet peak is the next summit northwesterly from the Black Eagle, or northerly from Crow mountain, and its steep, gray ledges are very noticeable on the easterly side of the Blue mountain road at the summit, where the land begins to descend northerly. In this vicinity are several mines of the mineral popularly styled "pocket garnet," the pockets being merely large crystals, sometimes quite regular in form, but often in large amorphous masses. In the adjacent part of the fourteenth township is a mine, and a mill at which the mineral is separated.

He describes the deposit on Gore mountain more particularly.

> These mines are, perhaps, the most remarkable of their kind known; certainly the most notable in this section of the country. A zone perhaps 100 feet in thickness, richly charged with the mineral, here extends along the northerly face of the mountain, at an elevation of about 2800 to 2900 feet above the sea. The

---

[1] N. Y. State Mus. Bul. 15. p. 553.
Min. Ind. 1896. v. 5.

[2] Min. Ind. 1897. 6:21.

[3] Report of Superintendent of State Land Survey. 1896. p. 133–35.

country rock on either side is a hard gneiss, containing very little mica, though broken crystals of what appeared to be biotite or phlogopite were met with.

The remarkable feature of this deposit consists in the innumerable crystals of the so called pocket garnet with which it is filled. These crystals are almost as abundant as cobblestones in a bank of glacial drift; not by any means perfect crystals, but coarse, irregular clusters, of which the matrix may be estimated to contain from 10 to 15%, and in places 20% of its volume, all of deep red, irregular masses of mineral. They are found of all sizes, from small bits up to enormous pockets, a foot or more in diameter, and it is claimed that crystals of 3000 pounds in weight have been taken from this mine. These large crystals, however, are not permanently knitted together, for the decomposition of the enclosing rock seems to have penetrated them also, so that frequently the broken fragments can be picked out easily with a stick, knife or trowel, and fall into the hands of the collector as dull, ruby-colored, disintegrated masses. In some cases huge crystals crumble so easily that a shovel full of broken garnet can be taken from a single pocket in the rocks.

The Warren county garnet[1] occurs in a formation of crystalline limestone which appears to form the bed rock in the vicinity of Minerva and in the gneissoid rocks which adjoin it. Prof. J. F. Kemp finds, from specimens furnished him from the North River Garnet Co.'s deposits, that the immediate associate of the garnet there is a rock containing 60% hornblende and a very basic triclinic feldspar, probably anorthite. The following is his description of the geology of these deposits as printed in the *Mineral Industry.*

The wall rock contains a large percentage of quartz, fully 50%. With it are oligoclase and small amounts of orthoclase, microperthitic feldspar, hornblende, green augite and considerable pyrrhotite and zircon. This is a not uncommon rock in this section of the Adirondacks. Its granulation is due to pressure, and all the above minerals are shattered and strained by mountain-making upheavals. It was probably a rather feldspathic sediment originally that became metamorphosed to a gneiss, but it may have been a granite or similar rock now crushed and granulated. The garnet bed must be either a metamorphosed and originally impure limestone, which is most probable, or a very basic eruptive rock changed by metamorphism to its present state.[1]

---

[1] N. Y. State Mus. Bul. 15. p. 553.

The garnet occurs in masses of varying size, from pieces the size of an egg to masses having a diameter of 20 feet and more. The various qualities are distinguished commercially as massive garnet, shell garnet and pocket garnet. The massive garnet is very impure from the presence of other minerals. The shell garnet is the almost pure material and is the most desirable for industrial purposes. The pocket garnet occurs in small accumulations, incipient crystals, in the gneiss.[2] This Adirondack material, though of the common variety almandite, is however extremely hard, its hardness being 8., which is from 1.5 to .5 harder than the general hardness of this variety. Its popularity among garnet paper manufacturers is due to this extra hardness and a tendency to cleave more easily than other occurrences of the same variety.

Methods of extraction and preparation

The garnet is mined entirely by open cut work and was formerly picked out by hand. By this process only the very richest beds could be worked, and the decomposed surface portions usually determined the extent to which the deposit could be developed. The best garnet in the solid rock was left and covered over by the debris from the working of the surface material. In 1899 a new mechanical process was established by Mr F. C. Hooper, of the North River Garnet Co. of North River, Warren co., by which the rock was broken down by steam drills, crushed and the garnet concentrated by gravity. By this method, garnet, 95% pure, is obtained, an increase in purity of from 25% to 45% over the old method of hand-picking. This degree of concentration is remarkable when the difference in specific gravity between the minerals to be separated is less than .5. Specimens of pure garnet and pure hornblende from the North River Garnet Co.'s mines gave specific gravities of 3.2

---

[1] Min. Ind. 1898. 6:20.

[2] N. Y. State Mus. Bul. 15. 1895. p. 553.

and 3.7 respectively. Mr Hooper has not made public the details of his separation process, but, by its means, the present plant is capable of crushing and separating 150 tons of ore per day (1903).

The entire output of the mines of this company is sold to Herman Behr & Co., of New York city, Boston and Chicago. who have extensive plants for the preparation from the raw material of the various forms of garnet paper, etc.

H. H. Barton & Sons Co., of Philadelphia Pa., work mines on Gore mountain in close proximity to the mines of the North River Garnet Co. Here the garnet is found in pockets averaging from 5 to 10 inches in diameter, occurring near the summit of the mountain in a decomposed hornblende rock. The mines are all open cuts, workable material being found almost on the surface.

There is at present no plant connected with these mines. The product is all hand-picked. Further development of the property will probably render the erection of a mechanical separation plant a necessity.

According to figures furnished by H. H. Barton & Sons Co. the Gore mountain mines produced during 1902 about 1000 net tons.

The following table shows the production of garnet in New York State in recent years.

Year	Short tons	Value per ton	
1893	1475		
1894	294		
1895			
1896			
1897	1050	$40[1]	
1898	1686	28.77[2]	
1899	1656	28.33[2]	
1900	2508	28.35[2]	$40[1]
1901	2500	28.25[2]	

---

[1] Price of Adirondack material.

[2] This is the average price per ton for garnet from all localities in the United States. North River garnet brought a slightly higher price.

In 1899 some garnet was imported from Africa, but on practical test it was found to be inferior to the New York State material, and its importation was discontinued.

Uses of garnet

The ready cleavage of garnet makes it a most valuable abrasive in the leather and wood industries. Quartz and emery rapidly become dull, but the garnet, owing to its brittleness along cleavage planes, continually presents sharp cutting edges. The various grades of garnet paper are known commercially as sandpaper, garnet paper or shoe paper. It is of some use in the polishing and grinding of brass, but for other metals emery is considered better. A manufacturer of paper mill machinery has used garnet in place of emery for grinding joints of ironwork where the mineral is confined between two surfaces. In comparison with emery, only one half of the weight was required, and a perfect joint was secured in half the time.[1]

Garnet has been mixed with emery and corundum in wheels, but the combination was not successful.

Emery

Emery occurs within the United States at three localities along the Atlantic seaboard and at one or two places in the middle west. The eastern deposits are the most fully developed, and of these that at Chester Mass. is the most prominent. Emery is found in New York about 4 miles southeast of Peekskill and 2 to 3 miles east of the Hudson river. It occurs in a series of igneous rocks which have been intruded into the metamorphosed sediments of this region. These intrusions cover an area of over 15 square miles, lying mostly within the town of Cortlandt, whence they derive the name of the "Cortlandt series" given to them by J. D. Dana in 1880.[2] This series consists mainly of rocks of the gabbro family. Norites, diorites and peridotites are by far the most abundant. The principal associate of the emery deposits is a norite.

---

[1] Min. Ind. 9:299.

[2] Am. Jour. Sci. Ser. 3. 1880. 20:199.

Throughout the region covered by these intrusives are deposits of aluminous titaniferous magnetite. On the eastern and southeastern borders this ore becomes very aluminous with a proportionate decrease in the amount of iron, and in these portions it is mined for abrasive purposes.

Prof. G. H. Williams, in a paper on the norites of the "Cortlandt series,"[1] published the results of a very careful study of these deposits. It was his opinion, after extended microscopic inspection of this material, that it consisted chiefly of an iron-magnesian spinel (hercynite), and that there was a striking similarity between these ores and certain magnetite deposits at Routivara, Sweden. Prof. J. F. Kemp has remarked a like similarity between these deposits and certain of the emery deposits in North Carolina. The latter are not, however, titaniferous to any marked extent.[2]

The deposits according to Professor Williams are segregations of the basic minerals of the norite, the purest of the emery being found to contain all the component minerals of the norite.[3]

An inspection of a series of thin sections of material from these deposits[4] under the microscope showed that they consisted of hercynite, magnetite and corundum of a very light color. Of these minerals the hercynite was by far the most abundant, forming in some cases over 50% of the material in the slide. The corundum occurs in small crystals containing medial inclusions of what appeared to be magnetite. Magnetite in grains showing a crystalline outline is also included in the hercynite.

The proportions of corundum and hercynite are very variable. In some specimens the corundum will make up over 50% of the slide, while in others the material is almost 100% hercynite.

The hercynite is inferior in hardness to the corundum, corundum being 9 in the scale of hardness, while hercynite is about 8. This softness is in some measure compensated by the more ready cleavage of the hercynite, which causes it always to present fresh, sharp cutting edges. It is claimed by manufacturers of emery products that this Westchester material is extremely serviceable when made into wheels[1] with a vitreous bond, excelling the emery from other localities in this particular form of wheel.

---

[1] Am. Jour. Sci. Ser. 3. 1887. 33:194.

[2] Kemp, J. F. School of Mines Quarterly. July 1899. p. 345.

[3] Am. Jour. Sci. Ser. 3. 33:196.

[4] A series of slides of this material was furnished the author by the kindness of Prof. J. F. Kemp, of Columbia University.

The deposits of emery occur irregularly and vary very considerably in size. Some openings have yielded over 100 tons without showing signs of exhaustion, while others yield a scant 20 tons or less. The mines are located on the outcrops of the ore, which are often discovered by the turning up of fragments while plowing in the fields. They are all open cuts, varying in width and depth with the size of the ore body. The ore is blasted out by light charges of explosives and is broken up and roughly cobbed to remove the greater part of the impurities before shipping to the mill.

In the early history of these mines the ore was smelted in the blast furnaces of the neighborhood for the iron it contained. There it proved so refractory that this method of treatment was soon abandoned. Dr J. P. Kimball in 1874 wrote a paper advocating the use of this ore as a lining for puddling furnaces and as a source of multibasic slags.[2] It was never used in this connection to any great extent. In this paper Dr Kimball published four analyses of the Peekskill ore, which were made for him by C. F. Chandler and F. A. Cairns. These, together with analyses of the ore by T. M. Drown and T. Egleston and three analyses of the associated rocks published by J. F. Kemp in his *Handbook of the Rocks*, are reprinted in the accompanying table.

---

[1] Min. Ind. 1901. 10:17.

[2] American Chemist. 1874. 4:321.

Table of analyses of ore and associated rocks

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SiO_2	1.13	1.04	2.88	.51	.32	6.82	13.97	....	....	....	....	....	....	....	54.72	55.84	47.41
Al_2O_3	45.58	36.46	34.47	39.36	41.28	45.29	20.95	31.93	40.77	37.78	37.43	36.49	41.66	46.58	17.79	16.37	6.39
FeO	21.14	18.49	17.92	45.86	....	....	....	....	....	....	....	....	....	....	6.03	7.54	4.80
Fe_2O_3	25.86	28.21	28.7	....	....	....	....	18.19	18.37	24.35	21.17	21.36	23.71	32.31	2.08	.77	7.06
CaO	....	....	....	.47	....	....	....	....	....	....	....	....	....	....	6.84	7.51	14.32
MgO	....	....	....	7.18	....	....	....	7.41	6.73	7.92	7.20	8.39	7.91	9.43	5.85	5.05	15.34
MnO	....	....	....	.55	....	....	....	....	....	....	....	....	....	....	....	....	....
Cr_2O_3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
TiO_2	3.88	3.52	4.41	2.41	3.9	1.9	4.15	1.12	1.08	.62	.65	.67	.54	.51	....	....	....
P_2O_5	.16	.09	.16	.22	....	....	....	tr	tr	tr	tr	tr	tr	tr	....	....	....
Fe	34.54	34.13	34.03	34.44	35.82	29.16	40.32	....	....	....	....	....	....	....	....	....	....
H_2O	....	....	....	1.18	....	....	....	....	....	....	....	....	....	....	....	....	....
Silicious residue	....	....	....	....	....	....	....	6.42	1.04	11.19	13.14	10.08	11.48	2.42	....	....	....
Sulfur	....	....	....	....	....	....	....	.04	.04	.02	.02	.02	.01	.01	....	....	....
Fe_3O_4	....	....	....	....	....	....	....	34.20	32.01	17.37	19.81	22.77	14.76	8.98	....	....	....

1, 2 and 3 from Am. Inst. Min. Eng. Trans. 1881. 9: 19. T. M. Drown analyst.
4, 5, 6 and 7 from Am. Chemist. 1874. 4: 321. C. F. Chandler and F. A. Cairns, analysts. No. 4 had also FeS_2 2.63.
8 to 14 inc. from Am. Jour. Sci. March 1887. p.197. T. Egleston, analyst.
15, 16, 17 from Handbook of Rocks. J. F. Kemp, p.49. Have also (15) Na_2O 3.02 and K_2O 3.01. Gabbro
(16) " 5.09 " " .96. Norite } of Cortlandt series
(17) " .69 " " .20. Peridotite

In a contribution to the *American Journal of Science* on the limestone belts of Westchester county, Prof. J. D. Dana[1] in 1880 made mention of the presence of corundum in iron ores from this locality. Though he did not arrive at a true understanding of the mineralogic composition of these deposits owing to his error in mistaking for chlorite, what Professor Williams later proved to be hercynite, he drew attention to the abrasive quality of the material. A short time afterward an emery mill was established at Peekskill by the New York Emery Co., which for a time ran on the ore from the immediate vicinity, but it gradually abandoned the Peekskill ore, till in 1887 it was run almost exclusively on emery from Asia Minor. It was finally closed up and has not been reopened.

At the present time two companies are engaged in mining this ore, the Tanite Co. of Stroudsburg Pa., which controls most of the product, and the Ashland Emery and Corundum Co., formed[2] in 1900 by a combination of several of the leading emery mills in the country. The output of this region was estimated at over 1000 tons for 1896.[3] An estimate of the average annual output made in 1898 was from 500 to 700 tons per annum.[4] From the rapid growth of industries making use of the finished products and recent developments in methods of manufacture, a large increase in the output is to be expected.

Mill treatment

The final cleaning and grading of the roughly cobbed material received from the mines is carried on by several different methods which vary with the character of the matrix.

The Norton Emery Wheel Co. of Worcester Mass. treat the rough material by the following process, a description of which was furnished to the writer by Mr Charles L. Allen, manager of the company. The lumps are first crushed in a large stone crusher which reduces them to smaller pieces, they then pass through a smaller crusher; and from there they pass successively over six sets of rolls. The idea is to crush as little as possible each time, so that the minimum quantity of fine powders is obtained, as the manufacture of wheels demands a large proportion of the coarser grains. From the rolls the material is passed through washers, then driers, and from the driers it goes to the graders. Here it is screened, the various powders resulting from the screening being known by the number of meshes to the square inch in the sieve through which they have passed. The coarsest used is 14 and the finest 180. Between these two limits the grades run 16, 20, 24, 30, 36, 46, 60, and then by tens up to 180.

---

[1] Am. Jour. Sci. Ser. 3. 20:9, 199.

[2] Min. Ind. 1901. 10:18.

[3] Min. Ind. 1900. 9:16.

[4] Am. Inst. Min. Eng. Trans. 28:567.

In the Sapphire mills of the Hampden Emery Co. of Georgia and North Carolina, where the material handled is embedded in a soft chloritic matrix, the material on coming from the mine is hoed with wooden hoes in inclined troughs filled with running water. It is then crushed and passed over a 14 mesh sieve. The portion which passes through the sieve is then treated by what is known as the muller process. The crushed and screened material is placed in a circular trough and is there agitated by two heavy wooden rollers each 5 feet high. These rollers are attached to a revolving shaft which rises through a platform in the center of the trough. This trough is kept full of water. The cleansing of the material is effected by the rubbing of the hard grains of emery one against the other, thus wearing off the softer matrix, which, being light, is carried out by the water flowing over the central platform, the heavy emery remaining in the bottom of the trough. After being subjected to this muller process for from three to five hours, the material left in the bottom of the trough is removed and dried by one of many hot air processes. In the Sapphire mills it is dropped down a chimney on a soapstone slide a distance of about 20 feet. It is then crushed in rolls and sorted into various grades by screening.

The finest of the numerous grades are again rewashed and sorted by what is known as the elutriation process. The powders are suspended in water and forced through a set of tanks or cylinders, each 3 feet high and varying from 3 inches to 40 inches in diameter. That portion of the material that can no longer be supported by the decreasing strength of the current as it passes from the smallest to the largest tank, settles to the bottom and is afterward drawn off. Any impurities that may have passed through the first cleaning process pass out with the surplus water. The powders thus obtained are dried and are then ready for market.[1]

In this condition the emery is purchased by the manufacturers of emery products, who make it up in wheels, stones, emery paper, emery cloth, etc.

The wheels are made by binding the grains with some cementing material. Celluloid, rubber, silicious and vitreous bonds are used, each being specially adapted to certain classes of work. The required amounts of emery and bond are carefully measured out, thoroughly mixed, tamped into a mold and put in a kiln. The temperature of the kiln varies from about 300° F. in the case of vitreous bond to 150° F. when the least refractory bonds are used.

A bond composed of sodium silicate and zinc oxid is used by the Standard Emery Wheel Co. of Easton Pa., which till 1903 was located in Albany N. Y. This bond set at a very low temperature, no fusion being required.

On removal from the kiln, the wheels are trued and shaped in a lathe, the cutting of the wheel being accomplished by the use of black diamond (carbonado).

Much of the success of an emery wheel depends on the selection of a bond suitable to the work to be accomplished. It is therefore the present practice, when ordering emery wheels, to specify the work which is to be accomplished by the wheel, leaving the manufacturer to combine his materials to suit that particular case.

---

[1] The above description is condensed from an article by C. N. Jenks on corundum. Min. Ind. 1896. 5:26.

Large amounts of the various grades of emery are used in the manufacture of emery paper and emery cloth, in which form it is used in the process of tool manufacturing and in almost all metal industries. Quantities of powder are sold to the same manufacturers for use in the grinding of joints and polishing metal.

In 1894, 250 tons of powder were consumed in the glass beveling industry. Emery paper and cloth are used in large quantities by shoe manufacturers, woodworkers and brass founders; but in these industries it finds a strong competitor in garnet products.

During the year 1894, Mr C. N. Jenks, of Asheville N. C., made a series of very careful tests on the cutting properties of various abrasive materials. The tests were made on wheels of uniform size which were prepared under his personal supervision. The raw materials from which these wheels were made were purchased in the open market. They were subjected to tests carefully planned and watched, which were as nearly equal for each wheel as it was possible to make them. The following list gives the materials tested in the order of their cutting quality.[1]

1 Diamond
2 N. C., Jackson county, corundum
3 N. C. and Ga. corundum, known as "Standard"
4 Chester Mass. emery
5 Best Turkish emery (Abbotstone)
6 Bengal India emery
7 Naxos emery
8 Peekskill N. Y. emery
9 Garnet. N. C., in chloritic matrix
10 Carborundum
11 Crushed steel
12 Best flint quartz and ordinary garnet
13 Common quartz and burstone, flint, sand, etc.

---

[1] Scientific American, Supplement, Dec. 8, 1894. No. 988.

Diatomaceous earth

The deposits of diatomaceous earth occurring within the limits of this State are at present of but little economic importance, the majority of this material being supplied from localities in the west. The following is taken from a description of these deposits published by F. J. H. Merrill in bulletin no. 15 of the New York State Museum.[1]

Diatomaceous earth occurs in New York State at White Lead lake in Wilmurt, Herkimer co., and on the property of Dr Oliver Jones at Cold Spring Harbor L. I. This material consists of hydrated silica. The deposits are accumulations of the silicious skeletons of minute plants known as diatoms. They accumulate in the bottom of ponds and lakes and are of recent age as well as Tertiary or Cretaceous. Though living diatoms are abundant in all the waters of the State, deposits have been found only at the above mentioned localities.

The deposit at White Lead lake is owned by Mr J. W. Grosvenor and is the only one worked at present. The material is dug from the bottom of the lake, washed and run through strainers into settling vats, where it stands for 24 hours. The water is then drawn off and the residue shoveled into a press. It is here pressed into blocks 4 feet square and 4 inches thick, which are cut into cakes 1 foot square and piled under sheds to dry. The following analysis of the White Lead lake material was made by Mr Gideon E. Moore of New York.[2]

Water and volatile matter	12.12
SiO_2	86.515
Al_2O_3	.449
Fe_2O_3	.374
CaO	.12
Undetermined	.422
	100

---

[1] N. Y. State Mus. Bul. 15:555.

[2] Bul. 15:556.

While constructing the road bed of the Malone & Mohawk Railroad, numerous deposits of diatomaceous remains were discovered in the small lakes and ponds of the region adjacent to the line of the road. A careful investigation of the largest of these was made during 1893 and 1894 by Mr D. C. Wood, engineer in charge of Dr W. S. Webb's Nahasane park. The results of his investigations were published by Mr C. F. Cox in a paper read before the New York Academy of Science in 1894.[1] The survey was made with the idea of the development of these deposits on an economic basis, and Mr Wood reported eight ponds as containing these remains in sufficient quantity to be worked at a probable profit. The material in these eight ponds was exceedingly clean and covered from 2½ to 3 acres in each pond, ranging in depth from 1 foot to 12 feet.

In specimens of the material from the various localities discovered by Mr Wood, Mr Cox found 16 genera and 40 species of diatoms, the most abundant being Stauroneis, Cymbella, Eutonia, Navicula, Surirella, Melosira, Gomphomena and Epithemia.

In a previous paper[2] Mr Cox discusses the deposit at White Lead lake near Hinckley in Herkimer county. Here he found the same genera as in the other deposits. The remains of the genus Surirella were not so numerous as in the deposits to the north.

Mr Cox inferred from the presence of both fixed and free swimming forms that the deposits were not entirely lacustrine in their origin, the inflowing streams having contributed a portion of the deposit represented by the skeletons of the fixed forms, Melosira, Gomphomena, Epithemia etc.

Millstones

Material suitable for millstones is found in the Shawangunk grit (Oneida conglomerate) of Ulster county, N. Y., in Lancaster county, Pa., where it is called Cocalico stone, and in Montgomery county, Va., where it is known as Brush mountain stone. The New York material is sold under the name of Esopus stone. The

---

[1] N. Y. Acad. Sci. Trans. 1894. 13:98.

[2] N. Y. Acad. Sci. Trans. 1893. 12:219.

Shawangunk grit from which it is quarried is a light gray quartz conglomerate. The quartz pebbles are usually of a milky color and vary in size from a diameter of $\frac{1}{16}$ inch to a diameter of $1\frac{1}{2}$ inches. The matrix is a gritty silicious paste. These grits begin at High Falls and extend with increasing hight into Pennsylvania. The beds are of unequal thickness but of the same general character throughout the county.

The method of quarrying is very simple. A large block of stone is separated by means of its natural lines of bedding and jointing. It is then roughly dressed to shape by wedges, holes being drilled into which the wedges are driven. A final tool dressing fits the stone for market.[1]

These stones vary in size and also in price. For milling, stones are furnished from 15 inches to 7 feet in diameter. The larger stones or "Chasers" are used in grinding and crushing quartz, feldspar, etc. The smaller stones are used principally in portable mills for grinding cement, plaster, paint, and corn. Blocks of this material, 12 by 10 by 12 inches, are used in paving the chaser floors. In 1893 the large stones 7 feet in diameter brought prices between $50 and $100. The smaller stones sold from $5 to $15 and upwards. The introduction and increasing adoption of the roller process in flour mills and other industries caused a great decrease in the total annual value of this industry,[2] but recently the output has begun to expand.

To Mr James S. Van Etten the writer is indebted for the subjoined list of producers of Esopus stone for 1903.

Miles Decker	Granite N. Y.
James S. Van Etten	Granite N. Y.
Ambrose Van Etten	Granite N. Y.
W. H. Rose	Accord N. Y.
James Jonsbury	Kerhonkson N. Y.
Joseph Davis	Kerhonkson N. Y.

---

[1] N. Y. State Mus. Rep't State Geologist. 1893. p. 393–94.

[2] Rep't N. Y. State Geologist. 1893. p. 393–94.

Alundum and carborundum

Alundum

In 1902 the Norton Emery Wheel Co. of Worcester Mass., established a plant at Niagara Falls for the production of artificial corundum from the mineral bauxite. This artificial product is called "alundum" by the manufacturers, who have not as yet made public the process of manufacture.

From figures kindly furnished by the Norton Emery Wheel Co., the following table showing the relative amounts of pure crystalline corundum in the natural ore and manufactured product, has been prepared.

AVERAGE ANALYSES OF CORUNDUM

	Al_2O_3	Fe_2O_3	S_1O_2	Loss
Best Turkish emery	67.89%	26.72%	5.37%	
" Naxos emery	69.13%	25.46%	2.57%	2.19%
" India emery	90.06%	4.25%	5.17%	.77%
Alundum	97.99%	1.50%	.95%	

At present the entire output of the factory at Niagara Falls is consumed by the home company. It is expected by the management that it will soon be in condition to place large quantities on the market. Large demand for this product has already been made, and it bids fair to prove a powerful competitor of carborundum.

Carborundum

Process of manufacture and refinement

Carborundum is a carbid of silicon, in its crude state, a lustrous irridescent mass of tabular hexagonal crystals. Its chemical formula is CSi, and it closely approaches the diamond in hardness. Absolutely pure carborundum is white. In commercial manufacture the crystals are produced in many colors and shades, partly as a result of impurities, and partly owing to surface oxidation. The prevailing colors are green, black and blue.

Sand, coke, sawdust and salt are the raw materials from which carborundum is made. In early experiments clay was used instead of sand, but it was soon discovered that the silica of the clay was the only portion consumed in the process of manufacture, and a good glass sand was substituted. The process of manufacture as described by Mr Francis A. Fitzgerald in a lecture delivered before the Franklin Institute on Dec. 11, 1896, is as follows:[1]

The crude materials for the manufacture of carborundum, viz, sand, coke, sawdust and salt, are received in the stock building. These are ready for immediate use, with the exception of the coke, which must be reduced to kernels of a certain size to be used as "core" and ground to a fine powder to be used in making the mixture or charge for the furnaces. To effect this, the coke is first passed through a grinder, which breaks it up into small pieces, and is then conveyed to the upper part of the building, where it is passed successively through two cylindrical screens. The first of these removes all particles of coke which are too small to form the core, while the second allows kernels of the requisite size to pass through its meshes and fall into the core bin, conveniently situated as regards the other constituents of the mixture. Below this bin are scales on which the sand, coke, sawdust and salt are weighed out in proper proportions, and then conveyed by an elevator to a mechanical mixer, from which the mixture, ready for use, is emptied into a bin. The arrangement of the machinery connected with all this work is such that it can be attended to with ease by two men.

The furnace room is built to accommodate 10 furnaces, though at present there are but five. The furnaces are built of brick and have the form of an oblong box, the internal dimensions being, approximately, 16 feet in length, 5 feet in width and 5 feet in depth. The ends are built up very solidly, with a thickness of about 2 feet. In the center of either end are the terminals, consisting of 60 carbon rods 30 inches long and 3 inches in diameter. The outer ends of the carbons are inclosed in a square iron frame, to which is screwed a stout plate, bored with 60 holes corresponding to the ends of the carbon. Through each of these holes is passed a short piece of 3/8 inch copper rod, fitting tightly in a hole drilled in the carbon. Finally, all the free space between the inside of the plate and the ends of the carbons is tightly packed with graphite. Each plate is provided with four projections, to which the cables conveying the current may be bolted. These ends are the only permanent parts of the furnace; the remainder, which we shall now consider, is built up every time the furnace is operated.

---

[1] From notes of lecture published in pamphlet form by the Carborundum Co.

The side walls of the furnace are first built up to a hight of about 4 feet. Pieces of sheet iron are then placed at a distance of about 4 inches from the inner ends of the carbon terminals in such a way as to keep the mixture from coming in contact with the latter. The mixture is then thrown into the furnace till it is rather more than half full. A semicircular trench, having a radius of 10½ inches and extending from end to end of the furnace, is now formed, the bottom of the trench being a little above the level of the bottom row of carbons. Into this trench is introduced the core, which has been carefully weighed, so that the amount required to make the core of the right size is used. One of the furnaces at Niagara Falls requires about 1100 pounds of "new core," that is to say, core which has come directly from the bins, or about 850 pounds of "old core," or core which has already been used in the furnace. The reason for this difference in weight will appear later. All the core having been emptied into the trench, the top is rounded off neatly by hand, so that, when finished, we have a solid cylinder 21 inches in diameter and about 14 feet long, composed of small pieces of coke and extending from the sheet iron plate at either end of the furnace.

The next operation is to make the connections between the core and the terminals. This is done by packing finely ground coke into the spaces between the ends of the carbons and the pieces of sheet iron, after which the walls are built up to a hight of about 5 feet, the pieces of sheet iron removed, and more mixture thrown in and heaped up to a hight of about 8 feet.

All that is required now to make carborundum is the electric current.

After the circuit has been closed in the transformer room, no apparent change occurs in the furnace for about half an hour. Then a peculiar odor is perceived, due to escaping gases, and, when a lighted match is held near the furnace walls, the gas ignites with a slight explosion. When the current has been on for three or four hours, the side walls and top of the furnace are completely enveloped by the lambent blue flame of carbon monoxid gas, formed by the combination of the carbon of the coke with the oxygen of the sand. During the run of a single furnace 5½ tons of this gas are given off. At the end of four or five hours the top of the furnace begins to subside gradually, and fissures form along the surface, from which pour out the yellow vapors of sodium. Occasionally the mixture on the top of the furnace is not sufficiently porous to allow the rapid escape of the gases. The result is that the latter accumulate until the pressure is so great that, at some weak point in the mixture above, a path is forced open and the gases rush out violently. This is termed "blowing" by the workmen. It is mainly for the purpose of avoiding this "blowing," that the sawdust is put in the mixture, since the former, by making the mixture porous, allows the gases to escape freely.

At the end of about 36 hours the current is cut off from the furnace, and it is allowed to cool for a few hours. Then the side walls are taken down and the unchanged mixture raked off the top of the furnace, till the outer crust of amorphous carborundum is reached. The crust is cut through with large steel bars, and can then be easily removed from the inner crust of amorphous carborundum. The inner crust is next removed with a spade and the crystalline carborundum exposed.

After the carborundum has been removed from the furnace, it is taken to a crusher, which consists of a large iron pan, rotated in a horizontal plane by means of a vertical shaft. A horizontal shaft, carrying two heavy rollers, is attached to a collar surrounding the vertical shaft, thus permitting a free vertical motion of the rollers which rest in the pan. The latter, in revolving, causes the carborundum to pass under the rolls, which break the mass of crystals apart. From the crusher the carborundum is taken to large wooden tanks, where it is treated for several days with diluted sulfuric acid to remove impurities. It is then thoroughly washed, dried and graded. There are 20 grades of crystals, from no. 8 to no. 220, the numbers indicating the meshes to the linear inch of the screen through which the crystals have passed. The washings from the crystals pass through a series of tanks which serve to collect the fine powders, and from these are made the so called "flours" and the hand-washed powders. The former are obtained by floating the ungraded powders in a stream of water flowing through a series of tanks, in which the powder settles.[1] There are three grades of "flour," designated, according to their fineness, F, FF, FFF. The hand-washed powders are obtained by stirring up a quantity of ungraded powder with water, allowing this to settle for a definite time, six minutes for example, then pouring off the supernatant liquid. The powder which afterward settles from this liquid is called six minute powder. In a similar way other hand-washed powders are made—one, four, 10 and 15 minute powders.

This artificial product is rapidly replacing garnet, emery and quartz in the various industries where the latter have long been held as superior material. Carborundum grains held together by some strong binding material form an abrasive surface, that is said to be more efficient for certain classes of work than the natural sandstones and grits used for grindstones and oilstones.

---

[1] An elutriation process similar to that employed in grading emery. *See* page 169.

Carborundum is manufactured only at Niagara Falls. The output of these factories for 1902 was 3,741,500 pounds and for 1903 was 4,759,890 pounds.

Oilstone

About 20 years ago the Labrador Oilstone Co., of Manlius N. Y., quarried stone from a portion of the Portage formation which outcropped on the side of Labrador mountain in the town of Truxton, Onondaga co. This rock was milled and dressed in Manlius. It was a hard, dark blue sandstone of medium coarse grain. It had fair abrasive qualities, but imparted a rough edge; and did not compare favorably with other stones then on the market. Its sale was extremely limited, and its manufacture was abandoned.

The Pike Manufacturing Co. of Pike Station N. H. states that at one time it operated the mill at Manlius, but none of its raw material was quarried within the boundaries of New York State.[1]

Bibliography

Garnet

N. Y. State Mus. Bul. 15. 1895. p. 553–55.
——— 48th Rep't for 1894. 1895. 1:553–55.
——— Bul. 19. 1898. p. 225–26.
——— 51st Rep't for 1897. 1899. 1:225–26.
New York at the World's Columbian Exposition. 1893. p. 341–42.
Rep't Sup't State Land Sur. for 1896. 1897. p. 133–35.
Engineering and Mining Journal. 1897. No. 16. 68:461.
Min. Ind. 1901. 10:274.
——— 1900. 9:299.
——— 1899. 8:220.
——— 1898. 7:272.
——— 1897. 6:20.
——— 1896. 5:27.
——— 1895. 4:14.
——— 1894. 3:19.
Hooper, F. C. School of Mines Quarterly. January 1894. 16:124.

---

[1] The above history and description of this stone were kindly furnished to the writer by the Pike Manufacturing Co.

Emery

Merrill, F. J. H. N. Y. State Mus. Bul. 15. 1895. 3:555.

N. Y. State Mus. 48th Rep't, for 1894. 1895. v. 1, p. 555 (2d paging).

Merrill, F. J. H. N. Y. State Mus. Bul. 19. 1898. 4:226.

N. Y. State Mus. 51st Rep't, for 1897. 1899. v. 1, p. 226.

19th Rep't N. Y. State Geologist, for 1899. 1901. p. 151–54; *also* N. Y. State Mus. 53d Rep't, for 1899. 1901. v. 1, p. 151–54.

Williams, G. H. Norites of Cortlandt Series. Am. Jour. Sci. Ser. 3. 1887. 33:196.

Dana, J. D. Limestone Belt of Westchester County. Am. Jour. Sci. Ser. 3. 1880. 20:199.

Kimball, J. P. American Chemist. 1874. 4:321.

Lewis, J. S. Am. Inst. Min. Eng. Trans. 1893. 25:881–86.

Blue, A. Corundum in Ontario. Am. Inst. Min. Eng. Trans. 28:567.

Jenks, C. N. Tests of Abrasive Materials. Scientific American, Supplement. Dec. 8, 1894. No. 988.

Pratt, J. H. Min. Ind. 1901. 10:17.

Eckel, E. C. Min. Ind. 1900. 9:15.

Jenks, C. N. Min. Ind. 1896. 5:26.

Millstones

Min. Ind. 1898. 6:16.

N. Y. State Mus. Bul. 15. 1895. 3:527.

——— 48th Rep't, for 1894. 1895. v. 1, p. 527 (2d paging).

——— Bul. 19. 1898. 4:223.

——— 51st Rep't, for 1897. 1899. v. 1, p. 223.

13th Rep't N. Y. State Geologist, for 1893. 1894. p. 393–94, 401–5. Millstones of Ulster County; *also* N. Y. State Mus. 47th Rep't, for 1893. 1894. p. 587–88, 595–99.

Diatomaceous earth

N. Y. State Mus. Bul. 15. 1895. 3:555–56.

——— 48th Rep't, for 1894. 1895. v. 1, p. 555–56.

Fox, C. F. N. Y. Acad. Sci. Trans. 1893. 12:219.

——— N. Y. Acad. Sci. Trans. 1894. 13:98.

Carborundum

Jour. Franklin Inst. September 1893.

Carborundum, pub. by Carborundum Co. 1900. p. 5–23.

School of Mines Quarterly. November 1894. 16:73.

Acheson, E. G. History and Physical Properties of Carborundum. Min. Ind. 1897. 6:12.

MINERALS NOT COMMERCIALLY IMPORTANT

BY HERBERT P. WHITLOCK

In addition to the productive mineral deposits of commercial value, there are, in New York, many mineral occurrences which would be of economic value were it not for the fact that their small extent and costly mining render the working of them profitless as a commercial enterprise. In many cases these deposits have been worked in the past and have ceased producing because of the thinning of the ore body or on account of growing competition with the richer and more productive mines in other sections of the United States. Gold, silver and platinum, while undoubtedly occurring to a small extent both free and combined (in the case of gold and silver) with pyrite or galena, have never been found in New York in sufficient quantity to pay for the cost of extraction.

The experience of 50 years tends to show that capital invested in New York gold and silver mining ventures has invariably resulted in a loss. Gold and platinum undoubtedly exist in extremely minute proportions in the garnetiferous and magnetic sands of the Adirondack region, and in the year 1898 alone 2800 gold and silver claims were filed in the office of the secretary of state, covering portions of Saratoga, Fulton, Warren, Hamilton, Herkimer, Essex, Clinton, Franklin, St Lawrence, Jefferson and Lewis counties. The writer is however unaware that any of the holders of these "claims" have succeeded in extracting gold in paying quantities.

The minerals unimportant commercially may be roughly classified in two groups: metallic minerals and nonmetallic minerals.

Metallic minerals

1 **Iron pyrites.** The bisulfid of iron commonly known as iron pyrites furnishes a cheap source of sulfur in the manufacture of sulfuric acid. Within the last few years its use in this industry

has been steadily replacing that of native sulfur. It is at present mined in but one locality in New York, though it is widely distributed in small deposits. Two minerals are included in the term iron pyrites: the common bisulfid of iron or pyrite and the orthorhombic iron bisulfid which is known as white iron pyrites or marcasite.

Pyrite is frequently mistaken for gold, owing to its brassy color and brilliant metallic luster. The principal localities in New York are:

Hermon, St Lawrence co. This deposit is situated in a belt of crystalline limestone about 5 miles south of Canton and near the town of Hermon. The ore is a massive pyrite, containing 38% to 40% sulfur and 2.75% copper.[1] The mines are now being operated.

Anthony's Nose, Westchester co. A deposit of massive pyrrhotite situated on the north slope of this mountain was formerly mined, but has been abandoned for some time.

Philip's ore bed, Putnam co. This constitutes a vein of magnetite of considerable extent in gneiss and was traced by Mather[2] for a distance of about 8 miles along the crest of the east ridge of the Highlands in the towns of Putnam Valley and Phillipstown. It was formerly worked at a number of places for magnetic iron ore. The limestone which here lies next to the gneiss carries considerable pyrite.

Deposits of a similar nature also exist at Paterson, 5 miles southeast of Carmel, and near Ludington mills in Putnam county.

Wurtsboro, Sullivan co. Pyrite occurs in this locality in cubic crystals associated with galena, sphalerite and chalcopyrite. The mine which was formerly worked for lead was abandoned about 12 years ago.

Root, Montgomery co. A deposit of massive pyrite associated with galena occurs at Flat Creek in this town about 1½ miles southeast of Spraker's Basin. The deposit was formerly worked for lead, but was soon exhausted.

---

[1] U. S. Geol. Sur. 1883–84. p. 879.

[2] Beck. Natural History of New York. p. 10.

Duane, Franklin co. An extensive bed of massive pyrite occurs in this town near the road leading to Malone.

Martinsburg, Lewis co. Crystallized pyrite in the form of modified octahedrons occurs in a vein of galena which traverses the limestone.

Schoharie, Schoharie co. Pyrite in well crystallized forms, single or in clusters, occurs in the limestone about 1 mile west of the courthouse.

Rossie, St Lawrence co. At the Rossie lead mines, which formerly produced considerable galena, large, brilliant and highly modified crystals of pyrite were obtained. These mines, however, have been abandoned for so long that it is difficult at present to obtain even cabinet specimens.

Eighteen Mile creek, Erie co. On the shore of Lake Erie near Eighteen Mile creek, pyrite occurs quite abundantly in the slate.

Marcasite, the white iron pyrites, do not occur to any extent in New York State, though small crystals have been found in the cement mines at Rondout, Ulster co.

2 **Arsenical pyrites.** Two compounds of arsenic and iron are here included: a sulpharsenid of iron known as arsenopyrite or mispickel and a diarsenid of iron of somewhat variable composition known as löllingite or leucopyrite. Both minerals are used to a limited extent in the manufacture of white arsenic. Owing to their brilliant, white, metallic color, they are often mistaken for silver ores, but, though the arsenopyrite of New South Wales frequently carries gold, precious metal has never been extracted from arsenical pyrites in this section of the United States. The principal New York localities follow.

Edenville, Orange co. Both arsenopyrite and löllingite occur in this locality; the former in both crystallized and massive varieties associated with gypsum and orpiment and embedded in white limestone; and the latter distributed throughout a black hornblendic diorite.

Kent and Boyd's Corners, Putnam co. This locality lies about 4 miles northwest of Carmel near Brown's quarry, a serpentine deposit which was formerly worked.

Specimens have been obtained from an old shaft about 40 feet deep, and the deposit, which consists of arsenopyrite, appears to be of the nature of a mass rather than a vein.[1] These localities have been opened but not worked for arsenic.

3 **Chromic iron ore.** Chromite, an iron chromate of variable composition, constitutes the chief source of the chromium pigments and of bichromate of potash used in calico printing. It is, furthermore, used to a small extent in the production of chromic steel.

Small amounts of chromite have been noted at the following places in New York State.

Phillipstown, Putnam co. Chromite occurs sparingly in the serpentine of Heustis's quarry about 5 miles northeast of Cold Spring. Occasional crystals have been met with in this locality.

Monroe, Orange co. Minute octahedral crystals of chromite occur at the Wilks or Clove mine about a mile south of the town of Monroe. The mineral is here found in talc associated with magnetite.

4 **Copper.** Though of relatively uncommon occurrence in New York State, copper ore is represented by several vein deposits, which were formerly worked in connection with the lead deposits in which it occurred as an associated mineral. The ore consisted of chalcopyrite, or copper pyrites, a sulfid of iron and copper. Cuprite, or red copper oxid, and malachite, the green basic carbonate of copper, also occur sparingly in isolated localities.

Copper pyrites

Ellenville, Ulster co. Chalcopyrite, in both crystallized and massive varieties, is found associated with the galena and sphalerite and disseminated through the crystallized and massive quartz. The mine, which has recently resumed work, consists of a vein of galena and sphalerite about 3 feet wide in Oneida conglomerate and is situated about ¼ of a mile from the railroad station. An incline runs to a depth of 115 feet with side galleries.

---

[1] Mather. N. Y. Geol. Report. 1839

Similar deposits occur at the old Ulster mine, 1 mile east of Red Bridge, and at a mine formerly operated for lead 2 miles northwest of Wurtsboro, Sullivan co.

Ancram, Columbia co. At the Ancram lead mines about 4 miles southeast of the town of Ancram, chalcopyrite occurs in the quartz which forms the gangue in the lead-bearing veins. For a further description of this occurrence, *see under* Lead.

St Lawrence county. Chalcopyrite was found associated with the galena at the Rossie lead mine, which has long since ceased operation, and at the pyrite locality near Hermon noted under that mineral. Small quantities of this mineral have been found associated with the arsenopyrites of Edenville, Orange co., and at many other localities in unimportant amounts.

Cuprite, the red oxid of copper, has been noticed in thin seams in the diabase near Ladentown, Rockland co., a locality which also furnished an occurrence of malachite, the green copper carbonate. Both minerals here occur in extremely small quantity.

5 **Lead.** The lead deposits of New York, which were formerly worked to a limited extent, consist principally of galena, a sulfid of lead. This mineral is dark gray in color, with a cubic cleavage and metallic luster, and closely resembles metallic lead. Small quantities of cerussite, a white carbonate of lead, have been found associated with the galena in some localities.

Rossie, St Lawrence co. The lead mines of Rossie, which were operated quite extensively from 1836 to 1839, are situated about 2½ miles southwest of the village of Rossie. The deposits consist of several veins in gneiss, the largest having a width from 2 to 4 feet with an outcrop exposed for about 450 feet. The ore consisted of galena, massive or frequently crystallized in large cubes, and associated with crystallized calcite, pyrite and chalcopyrite. Shafts were sunk to a level of about 150 feet and considerable ore extracted. The workings were however abandoned in 1839, and though they were reopened for a brief period in 1852, they have been inactive for forty years.[1] Similar deposits occur in the vicinity of Macomb and Mineral Point in St Lawrence county.

---

[1] Smyth, C. H. jr. School of Mines Quarterly. 1903. 24:421.

Ellenville, Ulster co. This mine, which has been already referred to under copper pyrites, consists of a vein deposit of galena and sphalerite or blende; the latter is of the variety known as "black jack." The galena contains a small percentage of silver. The mine is at present operated by the Ellenville Zinc Co. of Newark N. J.

At Red Bridge, Ulster co. and at Wurtsboro, Sullivan co., similar deposits in the same formation were worked for lead, but have been abandoned for some time.

Ancram, Columbia co. Galena occurs at the Ancram lead mines, about 4 miles southeast of the town of that name, in two or three veins from 3 to 4 feet in width in slate and limestone. The ore is poor in quality, being sparingly distributed through calcite and quartz, which constitute the gangue. It is associated with chalcopyrite, sphalerite and some barite. This mine was formerly operated for lead.

Besides the above mentioned localities, galena has been found sparingly at the following places.

Schoharie, Schoharie co. Associated with pyrite.

Ossining, Westchester co. In dolomite, associated with other lead minerals in small amounts.

North East, Dutchess co. Near Smithfield, associated with chalcopyrite and sphalerite.

Guymard, Orange co. Galena occurs at Guymard about 8 miles northeast of Port Jervis. This ore occurs in a fissure vein in Shawangunk grit and is associated with sphalerite. Shafts were sunk to considerable depth, one being carried down 400 feet. The mine has been abandoned for more than 15 years.

Root, Montgomery co. 1½ miles southeast of Spraker's Basin.

Vicinity of Martinsburg, Lewis co. In the Trenton limestone associated with pyrite, sphalerite and cerussite.

6 **Zinc.** Sphalerite, or zinc blende, a sulfid of zinc usually carrying some iron, constitutes the only zinc-producing mineral of New York. It is found chiefly associated with galena in the lead deposits and was formerly mined with that mineral. The

localities at which sphalerite has been found have, for the most part, been described under lead; briefly enumerated they are as follows:

Wurtsboro, Sullivan co. *See* under lead.

Ellenville, Ulster co. *See* under lead.

Ancram, Columbia co. *See* under lead.

Edenville, Orange co. Opaque, black variety.

Root and Flat Creek, Montgomery co. About 2 miles south of Spraker's Basin, light yellow transparent crystals associated with galena.

Salisbury, Herkimer co. Near Salisbury Corners, associated with galena, chalcopyrite, etc.

Vicinity of Martinsburg, Lewis co. A granular, massive variety, associated with pyrite and galena.

Rochester, Monroe co. At Pike's quarry in the Niagara dolomite, associated with galena, calcite and gypsum.

Lockport, Niagara co. A honey-colored or wax-yellow variety, often in transparent crystals in the Niagara limestone.

Clinton, Oneida co. Near Hamilton College, a yellow crystallized variety, nearly transparent. Also at Rome and Vernon in the same county.

Cooper's Falls, St Lawrence co. In a calcite vein.

Fowler, St Lawrence co. Associated with pyrite and chalcopyrite in a vein traversing serpentine.

Mineral Point, St Lawrence co. Massive, in a vein of galena.

7 **Manganese.** The ores of manganese are represented in New York State by the mineral wad, earthy manganese or bog manganese, a hydrated oxid of manganese. It is of comparatively rare occurrence and has little economic value.

Columbia county. Wad is found intimately mixed with the iron carbonates and limonites of this county at Hudson, Austerlitz and Hillsdale.

Houseville, Lewis co. On Tug hill, 2 miles south of Houseville, is a small deposit, earthy in character.

Warwick, Orange co. Four miles southeast of Warwick, a compact variety is found mixed with bog ore and earthy matter.

8 **Nickel.** Millerite, a sulfid of nickel, is occasionally found in pockets in the hematite at the Sterling mine near Antwerp, Jefferson co. The mineral occurs in radiating, hairlike crystals.

9 **Molybdenum.** A sulfid of molybdenum, known as molybdenite and resembling graphite in color and luster, is found sparingly in the rocks of New York State as follows.

Warwick, Orange co. Two miles southeast of Warwick, molybdenite occurs scattered in irregular plates through granite associated with rutile, zircon and pyrite. Molybdenite also occurs at West Point in this county.

Phillipstown, Putnam co. In the gneiss adjoining the Philips ore bed. *See* iron pyrites.

Brewster, Putnam co. Associated with serpentine and magnetite at the Tilly Foster mine.

Clinton county. Sparingly distributed through the granite rocks.

Nonmetallic minerals

1 **Fluorite.** Fluorite, or fluor spar, a fluorid of calcium, is found to some extent in St Lawrence county as well as in less important localities in the State. Fluor spar is used principally as a flux for iron, in the manufacture of opalescent glass and as a source of fluorin in the manufacture of hydrofluoric acid.

Macomb, St Lawrence co.[1] A cavity containing about 15 tons of finely crystallized fluorite in sea-green cubes, the latter often 12 inches on edge, was discovered in this town in 1889. The deposit was found in working a small vein in limestone, and the material, which furnished beautiful specimens, has been mostly distributed throughout mineral collections and cabinets. Smaller deposits of similar material have been found at the lead mines of Rossie and at Mineral Point, Hammond, Fine, Gouverneur and DeKalb in the same county.

Muscallonge lake, Jefferson co.[1] A deposit of flourite which was quite extensively worked 50 years ago occurs on the southeast bank of Muscallonge lake about 4 miles northwest of Oxbow. The material, which closely resembles the Macomb fluorite and occurred in a vein of considerable width in limestone, is now exhausted. Fluorite has also been noted at Vrooman's lake about 2 miles east of the above locality.

---

[1] Kunz, George F. Am. Jour. Sci. Ser. 3. 1889. 38:72.

Rochester, Monroe co. Fluorite occurs in the Niagara limestone at Pike's quarry.

Fayetteville, Onondaga co. Fluorite occurs in deep purple cubes associated with gypsum.

Theresa, Jefferson co. Fluorite occurs here associated with calcite and quartz.

Lockport, Niagara co. Fluorite occurs in the Niagara limestone associated with calcite, dolomite, gypsum etc.

Lowville, Lewis co. Green and nearly transparent crystals of fluorite occur in narrow veins in the limestone associated with calcite, pyrite and galena.

Johnsburg, Warren co. Beautiful crystals of fluorite have been found in this locality.

2 **Phosphate rock.** Apatite, a calcium phosphate of variable composition, is not found in New York State in deposits of sufficient extent to warrant its being mined as a fertilizer. The amorphous nodular phosphates, which in the southern Atlantic States constitute beds of considerable economic importance, are for the most part absent from New York formations.

Crown Point, Essex co. A fibrous, mammillary variety occurs 1 mile south of Hammondsville in this town. Crystallized apatite is also found associated with magnetite in many of the iron mines of Essex and Clinton counties.

Hammond, St Lawrence co. Large green and light blue crystals in calcite.

Gouverneur, St Lawrence co. About a mile southwest of Gouverneur, crystallized apatite occurs in limestone associated with quartz and wernerite.

Vrooman's lake, Jefferson co. Apatite occurs here crystallized in the limestone.

Natural Bridge, Lewis co. Imperfect crystals of apatite occur in decomposed white limestone near Natural Bridge, associated with orthoclase, wernerite, pyroxene and titanite.

Greenfield, Saratoga co. Reddish brown apatite occurs in a granite vein in the town of Greenfield about a mile north of Saratoga Springs.

Amity, Orange co. Two miles south of Amity, in a vein of white limestone, apatite is found in well defined crystals of a bright green color.

3 **Barite.** Barite, or barytes, the sulfate of barium, is often termed heavy spar on account of its relatively high specific gravity. Pure barite is rarely found in considerable masses, and the impure mineral as mined is invariably subjected to a careful sorting and refining treatment before being placed on the market. It is used as an adulterant for white lead and also to give weight and body to certain kinds of paper and cloth. Small deposits of barytes occur in a number of places in New York State.

Pillar Point, Jefferson co. Barite occurs on the Lee farm situated on the north shore of Pillar Point. The deposit consists of a vein of massive barite in limestone, which appears to run out into the bay for some distance. This vein was quarried about 40 years ago for paint adulterant.

Richville, St Lawrence co. Barite occurs here in translucent crystals with well defined terminations associated with calcite. At Hammond, De Kalb, Gouverneur, Rossie and Mineral Point in the same county similar occurrences have been noted.

Schoharie, Schoharie co. A fibrous variety of barite, grayish white or bluish white in color, occurs about 8 miles northwest of Schoharie courthouse in the town of Carlisle, between layers of dark colored slate. Also as a lamellar variety near the courthouse in waterlimestone associated with strontianite.

Little Falls and Fairfield, Herkimer co. On the south side of the Mohawk river opposite Little Falls, barite occurs crystallized in veins and geodes in the calciferous sandstone. It is white or bluish in color and sometimes transparent. Near the towns of

Little Falls and Fairfield a lamellar yellowish white variety has been observed.[1]

Syracuse, Onondaga co. At a point about ¾ of a mile east of Syracuse, crystallized barite is found in interlacing crystals associated with celestite in limestone.

Ancram, Columbia co. A white massive variety of barite occurs at the Ancram lead mine in veins traversing slate and limestone.

4 **Celestite.** Celestite, the sulfate of strontium, is used to some extent in the production of nitrate of strontia for the manufacture of fireworks. Its value for this purpose consists in its property of imparting a brilliant crimson color to the flame. The demand for it is however small, and it is not mined within the limits of New York State. Small deposits of celestite have been noted at the following localities.

Lockport, Niagara co. Celestite occurs at Lockport in grayish blue crystals, often semitransparent, in geodes in the limestone associated with calcite, dolomite and gypsum. Also in opaque white or bluish white lamellae and coarsely fibrous masses.

Rossie, St Lawrence co. At the Rossie lead mine celestite is found in delicate blue crystals associated with calcite.

Jefferson county. Near Starkville, Brownville, Depauville, Chaumont and Theresa.

5 **Magnesite.** Magnesite, a carbonate of magnesium, has a limited use in the manufacture of magnesium salts, such as Epsom salts, magnesia etc., and in the manufacture of paint, paper and fire brick. Small veins of magnesite occur in the serpentine formations of New York in several localities, but nowhere in commercial quantities.

Rye and New Rochelle, Westchester co. At New Rochelle and the vicinity of Rye and Port Chester the serpentine outcrops contain veins of magnesite. The mineral is massive, white in color and breaks with a conchoidal fracture somewhat resembling that of unglazed porcelain.

Tompkinsville, Richmond co. Magnesite here occurs in thin veins and cavities in serpentine.

---

[1] Beck, Lewis C. Natural History of New York. Mineralogy. 1842. p. 205.

Warwick, Orange co. A small outcrop of serpentine shows an association of magnesite in places.

Stony Point, Rockland co. Occurrence similar to that at Warwick.

6 **Mica.** Three distinct minerals are included commercially under this head. They are:

1 Muscovite or white mica, ordinarily known as isinglass

2 Biotite, or black mica

3 Phlogopite, or amber mica

Chemically the micas are all silicates of magnesium and aluminum; the black and amber micas also contain iron. Muscovite is extensively used in the doors of stoves and furnaces and for lamp chimneys, where its transparency and resistance to heat render it particularly valuable. Recently muscovite and phlogopite have been utilized as insulating material in electric apparatus, particularly for the armatures of dynamos. Ground mica, which is classed commercially as "scrap mica" as distinct from "sheet mica" described above, is used in the manufacture of wall paper. Mica is a common constituent in many of the rocks of New York and occurs in sheets in several localities.

Warwick, Orange co. Eight miles southwest of Warwick near Greenwood lake, muscovite occurs in a feldspar vein in plates sometimes a foot in diameter.

Monroe, Orange co. A deposit of greenish mica occurs in augite rock near Mombasha pond. The mineral is found in good sized plates and is now being mined.

Both muscovite and phlogopite are found in plates of varying size throughout Orange co. in the granite and gneiss rocks and at the contact of these rocks with limestone.

Pleasantville, Westchester co. A deposit of mica was at one time opened and mined at this locality, but has been abandoned.

Henderson, Jefferson co. A yellow, somewhat copper-colored mica, probably phlogopite, occurs in large plates near Henderson.

Pierrepont, St Lawrence co. At a point 1 mile north of Pierrepont muscovite occurs in plates which are often 7 inches across.

Edwards, St Lawrence co. Muscovite in plates and large prismatic crystals occurs at Edwards.

Elsewhere in St Lawrence county, muscovite and phlogopite are found in small amounts and, for the most part, in dark colored varieties.

7 **Coal and lignite.** Coal and lignite, while they occur in New York, can never be found in commercial quantities. The coal measures of Pennsylvania are not found north of the boundary line between Pennsylvania and New York, and what coal has been discovered in the latter state is in older formations, which do not contain this valuable mineral in commercial quantities. Many thousands of dollars have been spent in fruitless efforts to obtain coal in New York, but year after year persons who seem anxious to pay for their own experience appear in the field. It can not be too strongly urged on the attention of the people of the State that it is absolutely useless to seek for coal in New York.

Woodstock, Ulster co. Coal was formerly found in a thin vein in the Catskills. The vein is worked out.

Coal also occurs in seams interstratified with shales in Chautauqua, Erie, Livingston and Seneca counties.

Rossville, Richmond co. A thin seam of lignite, or brown coal, occurs in clay.

Lignite is also found sparingly in the clays of Suffolk county.

DISTRIBUTION OF HUDSON SCHIST AND HARRISON DIORITE

IN THE

WESTCHESTER COUNTY AREA OF THE OYSTER BAY QUADRANGLE

BY F. J. H. MERRILL ASSISTED BY H. C. MAGNUS

In 1900 that portion of the Oyster Bay quadrangle which falls on Long Island was mapped in detail by Prof. J. B. Woodworth and published in State Museum bulletin 48, entitled *Pleistocene Geology of Nassau County and Borough of Queens.* The northwest corner of this quadrangle falls within the limits of Westchester county and includes portions of the towns of White Plains, Scarsdale, Mamaroneck, Harrison and Rye. During the field season of 1903 Mr Harry C. Magnus has completed the mapping of the crystalline rocks of this district according to the classification and succession adopted by the author in the New York city folio. As no new points were developed in the course of Mr Magnus's work, the rock descriptions given here are identical with those used in the New York city folio. The map is of interest to students and teachers of the New York city region as supplementing the Harlem sheet published in the folio above mentioned.

Hudson schist. The schist of the New York district receives the name Hudson because it continues northward and connects stratigraphically with the great area of slate and shale along the Hudson river which have been called respectively Hudson slate and Hudson shale. The Hudson schist, Hudson slate and Hudson shale represent different phases of alteration of the same original rock, and together they form the Hudson formation. The Hudson formation continues into New England and is there a schist, which has been called the Berkshire schist.

The rock is essentially a mixture of biotite and quartz, but frequently contains enough orthoclase to give it the composition of gneiss. The principal accessory mineral is garnet, which occurs in crystals varying from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch in diameter.

Occasionally much larger crystals are found. Microcline, fibrolite, cyanite and staurolite are also frequent accessories. The Hudson schist has a marked schistosity, which is frequently, though not always, nearly parallel to the bedding.

The aspect of this formation is intimately affected by numerous igneous intrusions and injections of granitic and basic material, which in some places are so numerous as to predominate over the schist. The small masses are, for the most part, parallel to the schistosity, though occasionally oblique to it. The larger areas usually have their longer diameters parallel to the strike of the schistosity. They are most abundant near the shores of Long Island sound.

Harrison diorite. This rock is intrusive in the Hudson schist in the towns of Mamaroneck, Harrison and Rye. It consists of quartz, feldspar, hornblende and biotite, with accessory titanite and garnet, and less frequently apatite. The feldspars are orthoclase and plagioclase (probably oligoclase andesin) in about equal amounts, the two together making up nearly two thirds of the rock. The mass which forms Milton point, near Rye, has been subjected to much dynamic action and is well banded. The same rock is abundant along the shore of Long Island sound between Port Chester N. Y. and Stamford Ct. A small area of similar rock occurs at Ravenswood L. I., where it outcrops in a long, narrow ridge of northeasterly trend and is intrusive in the Fordham gneiss.

THE NORTHEAST EXTREMITY OF THE PRE-CAMBRIAN HIGHLANDS

BY F. J. H. MERRILL

With map by T. Nelson Dale

The northeast extremity of the Precambrian highlands of Putnam and Dutchess counties lies in an area of great geologic interest. This is due to the fact that the exposures there afford opportunity for the correlation and comparison of the crystalline formations of southeastern Dutchess county, with those of southern Putnam and Westchester. Reconnaissance surveys of this region were made during the period between 1896 and 1902 by F. J. H. Merrill and his assistants Benjamin F. Hill and Edwin C. Eckel. In August 1903, being in Pittsfield, the State Geologist had an opportunity of seeing a field map of a part of the district made in 1892 under the direction of Professor Raphael Pumpelly, by T. Nelson Dale and L. M. Prindle, field assistant. This map was on the scale of 2 miles to the inch and was so complete in minute detail, that it attracted the attention of the writer and Professor Dale kindly offered him the use of it for publication, subject to the approval of Director Walcott. The permission of the latter was most cordially given and the map appears in illustration of this paper. Professor Dale's notes are records of the outcrops and express no conclusions concerning the formations, the discussion on which is based on the writer's own studies in the district.

The area in question falls on the Clove topographic quadrangle, a portion of which is colored geologically to illustrate this paper. The rocks of the region are a Precambrian formation of gneiss; a basal Paleozoic quartzite of Lower Cambrian age; a Cambro-Silurian limestone, stratigraphically equivalent to the Stockbridge; and a highly metamorphosed crystalline schist, of Hudson age, equivalent to the Berkshire schist of the New England geologists.

Near Poughquag village is a most extensive exposure of the basal Cambrian formation which from this locality has received the name of Poughquag quartzite. This name, originally suggested by Dana, was adopted in the New York city folio as a substitute for the name Lowerre previously used by the writer and for the name Cheshire which had been, for some time, used in New England as a designation for this basal deposit. One of the reasons for this substitution was, that in the railroad cut southeast of Poughquag station, a Lower Cambrian fossil, *Hyolithes* sp. was found in the quartzite by Professor Dale and collections of it were made there by the man who acted as collector for Professor Dale. The name Poughquag has, therefore, a chronologic value as a designation for this formation because this locality has yielded Lower Cambrian fossils while at Cheshire Mass., no organic forms have yet been discovered.

The geologic structure in this area is not complex and the relations of the formations are clearly suggested by the map. The long contact of schist and gneiss was regarded by Professor Dale as a fault line but careful study of the region by the writer leads him to the opinion that it is more probably a case of overlap.

Professor Dale's party made no special study of the gneiss and schist and detailed petrographic examinations of these rocks in this district have not yet been made. The latter is a fine grained, hydromica schist and, at a point one half mile east of the contact, contains a considerable percentage of carbon in the form of graphite. The Precambrian gneiss in this region has some distinctive characters which are described as follows:

During the past 20 years the writer has been occupied, in the intervals of other work, with the study of the crystalline rocks of southeastern New York. The first task[1] accomplished was the differentiation of the principal members of the crystalline area and the determination of the structural relations of the quartzose and micaceous rocks to the great crystalline limestone which for many years was the only member accurately differentiated. With the identification of the Hudson schist and Poughquag quartzite came the recognition below the limestone of a great formation of banded gneiss, cut and injected at many points by later eruptives and of which nothing more could be said than that it was Precambrian.

---

[1] Am. Jour. Sci. 3. 39:383–92.

After extended reconnaissance and local study, in the Precambrian area, certain conclusions have been reached which make it possible to express more definitely the character of the Precambrian formations.

In the vicinity of New York city the prevailing rock is a gray and black banded gneiss, the gray bands consisting of quartz, orthoclase and biotite and the dark bands containing much biotite with some hornblende. With local variations in the proportions of the two materials of its banding, the general character of the rock persists throughout the Precambrian areas of Westchester county and it may be recognized here and there along certain lines in Putnam county, chiefly on the lower slopes of the mountain ranges as a rule showing a predominance of the lighter colored rock which is essentially a white feldspar gneiss with a small amount of biotite. The same characters prevail as one passes northeastward through Dutchess county over the Poughquag area and to Dover mountain and its Connecticut extension, the Kent-Cornwall area of Percival[1] who used the following description.

> The predominant rock of this formation is the white felspathic, dark mica-seamed granitic gneiss, varying, by the different proportions of its feldspar and mica, from a nearly white, thicker, more granitic variety, to a lighter or darker gray, thinner and more schistose variety.
>
> These variations occur in alternate beds, one or the other predominating in different sections of the formation.

Passing farther northeastward into Massachusetts one encounters the Becket gneiss formation of Emerson which has in places the same general characters.

The facts intended to be shown by the map are self-explanatory. Details of the geology of the Precambrian rocks are reserved for a separate paper on this subject which the writer has now in preparation.

---

[1] Percival. Report on Connecticut. New Haven 1843.

INDEX

The superior figures tell the exact place on the page in ninths; e. g. 189^{3} means page 189, beginning in the third ninth of the page, i. e. about one third of the way down.

Abrasives of New York State, by H. C. Magnus, 158^{1}-79^{7}.
Acheson, E. G., cited, 179^{8}.
Adirondack region, field work, 7^{5}.
Allen, Lucius E., cited, 131^{9}, 156^{6}.
Alloway, R. M., cited, 85^{7}.
Alundum, 174^{1}.
Ansted, D. T., cited, 85^{8}.
Apatite, 194^{5}.
Arsenical pyrites, 182^{5}-83^{2}.

Bach, A., cited, 85^{8}.
Bailey, A., cited, 85^{8}.
Bailey, E. H. S., cited, 134^{9}, 156^{9}.
Barite, 189^{3}-90^{2}.
Barnum, E. G., cited, 83^{9}, 86^{4}.
Baskerville, C., cited, 85^{9}.
Beck, Lewis C., cited, 181^{9}, 190^{9}.
Berkshire region, field work, 7^{1}.
Bibliography, of carborundum, 179^{7}: of diatomaceous earth, 179^{6}; of emery, 179^{1}; of garnet, 178^{6}; of gypsum, 156^{4}-57^{5}; of millstones, 179^{4}; of peat, 85^{7}-88^{4}.
Biotite, 193^{9}, 194^{4}, 197^{3}.
Bischof, Gustav, cited, 29^{9}.
Björling, P. R., cited, 85^{9}.
Blavier, cited, 85^{9}.
Blue, A., cited, 179^{3}.
Bog iron ore, 63^{5}.
Brande, cited, 86^{1}.
Brooklyn quadrangle, remapping, 8^{8}.
Byrne, cited, 86^{1}.
Byron, swamp, 84^{5}.

Caledonia, swamp, 85^{1}.
Carborundum, 174^{7}-78^{2}; bibliography, 179^{7}.
Carll, J. F., cited, 100^{9}.
Carter, W. E. H., cited, 35^{9}, 42^{2}, 56^{9}, 86^{1}.
Cassell, cited, 67^{4}.
Celestite, 190^{3}.
Charcoal, 52^{9}.
Chevalier, cited, 86^{3}.
Chromic iron ore, 183^{2}.
Cicero swamp, 74^{8}-77^{6}.
Clarke, J. M., cited, 112^{7}.
Clarke, William C., cited, 156^{7}.
Clay, 63^{1}.
Cleaveland, Parker, cited, 28^{1}, 86^{2}.
Cleland, mentioned, 7^{8}.
Climbing bogs, 26^{6}.
Clove topographic quadrangle, 195^{8}.
Coal, 192^{2}.
Coke, 52^{6}-56^{7}.
Cole, G. A. J., cited, 86^{2}.
Coleman, mentioned, 9^{3}.
Cook, G. H., cited, 86^{3}.
Coolidge, P. T., work of, 12^{4}.
Copper, 183^{5}.
Copper pyrites, 183^{7}-84^{5}.
Cowaselon swamp, 74^{5}.
Crystalline rocks, *see* Pre-Cambrian and crystalline rocks.
Cushing, H. P., field work, 7^{5}.
Cyanite, 194^{1}.

Dal, Adolf, cited, 42^{2}, 59^{9}, 86^{8}.
Dale, T. Nelson, map by, 195^{2}; mentioned, 7^{8}.
Dana, J. D., cited, 86^{8}, 167^{1}, 179^{3}, 196^{1}.
Dana, S. L., cited, 86^{3}.
Davy, Sir H., cited, 157^{4}.
Deuel swamp, 73^{9}-74^{2}.

Diatomaceous earth, 171^1-72^7; bibliography, 179^4.
Dieulafait, cited, 157^8.
Dingler, cited, 44^9, 48^9, 49^9.
Dutchess county, Pre-Cambrian highlands, 195^2.

Eckel, Edwin C., cited, 136^9, 179^4; surveys by, 195^4.
Economic geology, 12^9-13^5.
Ells, R. W., acknowledgments to, 12^2; cited, 86^4.
Emerson, cited, 197^8.
Emery, 163^6-70^9; bibliography, 179^1.

Fairchild, H. L., cited, 83^9, 86^4, 99^9.
Feldspars, 194^4, 194^5, 197^3.
Fibrolite, 194^1.
Fitzgerald, Francis A., cited, 175^2.
Fluorite, 187^5-88^5.
Fox, C. F., cited, 179^7.
Freeman, John R., cited, 71^9.
Fruh, cited, 86^4.

Garnet, 158^7-63^5, 193^9, 194^5; bibliography, 178^6; uses, 163^2.
Geddes, George, cited, 100^9.
Geologic map, 6^3.
Goldthwait, J. W., work of, 8^3.
Gowenlock, N., cited, 86^5.
Grabau, A. W., cited, 100^8.
Gregory, mentioned, 7^4.
Greycourt meadows, 72^3.
Grimsley, G. P., cited, 91^5, 133^2, 134^9, 156^9.
Gypsum, analyses, 148^9-55^3; bibliography, 156^4-57^5; Credner's theory, 94^1-95^6; theories of formation of deposits, 93^6-97^2; geography and topography, 97^4-105^2; geology, 105^2-14^6; history, 114^7-17^4; processes of manufacture, 126^7-30^7; list of firms and individuals that mine and manufacture, 155^4; list of manufacturers in New York who use gypsum from outside of this state, 156; New York mines and mills, 137^4-48^3; physical properties, 131^1-37^4; production, 148^4; sources of supply, 116^8; technology of, 130^7-55^8; uses, 117^3-25^1.
Gypsum industry in New York, by A. L. Parsons, 89-157.

Hall, James, cited, 106^3.
Harlem quadrangle, remapping, 8^3.
Harrison diorite in the Westchester county area of the Oyster Bay quadrangle, by F. J. H. Merrill and H. C. Magnus, 193^1-94^7.
Highlands, crystalline rocks, 6^9.
Hill, Benjamin F., surveys by, 195^4.
Hindshaw, H. H., tracings prepared by, 6^5; work of, 13^2.
Hitchcock, C. H., cited, 86^5.
Hitchcock, E., cited, 86^5.
Hobson, Joseph, acknowledgments to, 12^8.
Holland, John, cited, 86^6.
Hooper, F. C., cited, 178^9.
Hornblende, 194^4, 197^3.
Hudson schist in the Westchester county area of the Oyster Bay quadrangle, by F. J. H. Merrill and H. C. Magnus, 193^1-94^7.
Hulett, George A., cited, 131^3, 156^8.
Hull, E., cited, 86^6.
Hunt, T. Sterry, cited, 86^6, 157^3.
Hypsometric map, 6^6.

Infusorial earth, 63^2.
Inundated lands, 20^9-21^4.
Iron pyrites, 180^9-82^5.

Jackson, C. T., cited, 86^8.
Jenks, C. N., cited, 179^3, 179^4.
Johnson, C. W., cited, 157^5.
Johnson, S. W., cited, 45^9, 49^9, 50^9, 62^9, 86^7.
Julien, A. A., cited, 86^7.

Kane, Robert, cited, 86^8.
Keller, Theodore, cited, 86^8.
Kemp, J. F., cited, 160^6, 164^9.
Kimball, J. P., cited, 165^6, 179^3.
Kinahan, G. H., cited, 86^5.

Knapp, T., cited, 91^5, 126^9, 156^9.
Knapp's station, swamp, 80^3.
Kunz, George F., cited, 187^9.

Landrin, cited, 133^9.
Lead, 184^5-85^8.
Leavitt, T. H., cited, 50^9, 86^9.
Le Chatelier, Louis, cited, 132^9, 157^1.
Lesquereaux, L., cited, 25^9, 86^9.
Lewis, J. S., cited, 179^3.
Liebig, cited, 157^5.
Lignite, 192^2.
Little Falls sheet, areal mapping, 7^5.
Luther, D. D., cited, 113^9, 114^9.
Lyell, C., cited, 86^9.

McCaleb, cited, 156^6.
MacCulloch, J., cited, 86^9.
Madrid, bog, 79^8-80^5.
Magnesite, 190^6-91^3.
Magnus, Harry C., Abrasives of New York State, 158^1-79^7; Distribution of Hudson Schist and Harrison Diorite in the Westchester County Area of the Oyster Bay Quadrangle, 193^1-94^7; field work, 6^9.
Manganese, 186^7.
Mangrove marshes, 23^3.
Maps, *see* Geologic map.
Marignac, cited, 156^6.
Marine marshes, 21^9-23^1.
Marine shells, 9^6.
Marl, 62^8-63^1, 85^2.
Marsh, term, 21^5.
Marshes, salt, 21^4.
Mason, cited, 42^2.
Massachusetts, field work, 6^8.
Mather, cited, 183^9.
Merrill, F. J. H., Distribution of Hudson Schist and Harrison Diorite in the Westchester County Area of the Oyster Bay Quadrangle, 193^1-94^7; Northeast Extremity of the Pre-Cambrian Highlands, 195^1-97^9; cited, 93^9, 105^9, 156^8, 179^1.
Mica, 191^2-92^2.
Microcline, 194^1.
Millstones, 172^8-73^9; bibliography, 179^4.
Mineralogy, 13^5-14^8.
Minerals not commercially important, by H. P. Whitlock, 180^1-92^7.
Molybdenum, 187^2.
Montezuma marshes, 80^5-83^2.
Mooers quadrangle, mapping and study, 10^9; surface geology, 12^6.
Moore, J. S., cited, 87^1.
Moss litter, 38^7-39^6.
Müller, G., cited, 87^1.

Newberry, J. S., cited, 87^2.
Newberry, S. P., cited, 136^9.
Newton, W. E., cited, 87^2.
Nickel, 187^1.
Northeast extremity of the Pre-Cambrian Highlands, by F. J. H. Merrill, 195^1-97^9.
Northumberland rock, petrography of, 7^9.

Oak Orchard swamp, 83^7-84^5.
Ochsenius, cited, 157^4.
Oilstone, 178^3.
Orton, E., cited, 87^3.
Owl's Head, marsh, 78^8-79^7.
Oyster Bay quadrangle, distribution of Hudson schist and Harrison diorite in the Westchester county area, 193^1-94^7.

Page, W. H., cited, 87^3.
Paget, C., cited, 56^9.
Parsons, Arthur L., Peat, its Formation, Uses and Occurrence in New York, 15-88; Notes on the Gypsum Industry in New York, 89-157; cited, 156^8.
Patin, Charles, cited, 87^8.
Payen, cited, 157^1.
Peat, agricultural value, 61^7-62^7; analyses, 32, 34^1, 36^1; bibliography, 85^7-88^4; classification based on physical condition, 27^9-28^8; classification based on vegetation, 27^3; Connecticut, 34^5-35^4; definition

and description, 28^1; process of formation, 28^9-31^5; formation in swamps, 20^1; methods of determining fuel value, 36^4-38^1; use for fuel, 39^6-42^1; methods of preparing for fuel, 42^3-44^7; manufacture of fuel in Canada, 56^7-59^3; Irish, analyses of, 36^1; mechanical treatment, 44^7-59^3; Ontario, 35^4; Rhode Island, 33.
Peat, its formation, uses and occurrence in New York, by A. L. Parsons, 15-88.
Peat charcoal, 52^8-56^7.
Peat coke and volatile products, 59^3-61^7.
Pelouze, M., pére, cited, 87^8.
Percival, cited, 197^6.
Percy, John, cited, 42^2, 43^9, 44^9, 45^9, 46^9, 47^9, 48^9, 49^9, 50^9, 51^9, 52^9, 53^9, 54^9, 56^9, 87^8.
Phoenix, marsh, 78^4.
Phosphate rock, 188^5-89^3.
Pinnacle marsh, Rochester, 83^8.
Pleasant lake, swamp near, 77^7-78^3.
Pleistocene, 8^2-12^8.
Portland cement, 125^2-26^7.
Poughquag quartzite, 196^1.
Pratt, J. H., cited, 179^4.
Pre-Cambrian and crystalline rocks, 6^6-8^2.
Pre-Cambrian Highlands, northeast extremity, by F. J. H. Merrill, 195^1-97^9.
Protichnites, occurrence of trails of, 12^8.
Putnam county, crystalline rocks, 6^9; Pre-Cambrian Highlands, 195^2.
Pyrite, 180^9-82^5.

Quartz, 193^9, 194^4, 197^3.

Redgrave, cited, 157^1.
Rennie, R., cited, 87^4.
Ries, Heinrich, cited, 87^4, 136^9.
Rose, H., cited, 156^7.
Roth, J., cited, 87^4.
Rowlee, W. W., cited, 87^6.

St Lawrence valley, evidences of marine submergence, 9^4.
Salt marshes, 64^2-66^8.
Schöndeling, cited, 87^8.
Schroder, F. H., cited, 87^5.
Senft, F., cited, 87^5.
Severance, F. M., acknowledgments to, 91^4.
Seyfert, A. G., cited, 87^6.
Shaler, N. S., cited 19^9, 20^9, 64^9, 87^6.
Shell marl, 62^8.
Sherzer, W. H., cited, 87^8.
Smyth, C. H. jr, cited, 184^9.
Sperry, E. S., cited, 124^9.
Sphalerite, 185^9-86^7.
Staurolite, 194^1.
Stern, L., cited, 87^9.
Stevenson, William D., mentioned, 10^6.
Stissing pond, 72^5-73^8.
Stockhardt, cited, 157^5.
Storer, cited, 118^9, 121^9, 156^7, 157^5.
Swamps, oblation, 26^7-27^3; estimated area, 19^4; delta or estuarine, 25^7-26^1; description of, 21^8-27^2, 68^3-85^6; distribution in New York state, 63^6-68^3; economic value, 38^2-39^5; fresh-water, 21^8, 23^3; lake, 23^9-25^3; formation of peat, 20^1; all not peat deposits, 19^6; river, 25^3; term, 21^5; upland, 26^2; value, 19^8.

Taylor, Richard C., cited, 37^9, 87^9.
Thorpe, cited, 157^2.
Titanite, 194^4.

Vanuxem, cited, 105^3.
Vermeule, C. C., map prepared under supervision of, 6^5.
Vogel, August, cited, 45^9, 46^9, 54^9, 87^9.

Wagner, Rudolph, cited, 27^4, 91^6, 93^9, 157^2.
Wallkill, drowned lands, 63^3-72^3.
Websky, Justus, cited, 30^6, 88^1.
Westchester county, mapping, 7^1.

Westchester county area of the Oyster Bay quadrangle, distribution of Hudson schist and Harrison diorite, 193^1-94^7.
Wheeler, W. H., cited, 88^1.
White, cited, 88^2.
Whitlock, Herbert P., work of, 13^6; Minerals not Commercially Important, 180^1-92^7.
Wilkinson, Paul, cited, 157^2.
Williams, G. H., cited, 164^2, 179^2.
Williams, S. G., cited, 107^2, 112^9, 156^6.
Winchell, N. H., cited, 88^2.
Woodworth, J. B., work of, 8^2, 10^8, 12^6.
Wragge, R., cited, 88^2.

Zinc, 185^9-86^7.
Zirkel, cited, 88^2.

New York State Education Department

New York State Museum

PUBLICATIONS

Postage or express to places outside of New York State must be paid in addition to the price given. On 10 or more copies of any one publication 20% discount will be given, the buyer to pay transportation. Editions printed are only large enough to meet special claims and probable sales. When the sale copies are exhausted, the price for the few reserve copies is advanced to that charged by secondhand booksellers, in order to limit their distribution to cases of special need. Such prices are inclosed in [ ]. All publications are in paper covers, unless binding is specified.

Museum annual reports 1847–date. *All in print to 1892, 50c a volume, 75c in cloth; 1892-date, 75c, cloth.*

These reports are made up of the reports of the director, geologist, paleontologist, botanist and entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Geologist's annual reports 1881-date. Rep'ts 1, 3-13, 17-date, O; 2, 14-16, Q.

The annual reports of the early natural history survey, 1837–41, are out of print.

Reports 1–4, 1881–84. were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50		

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899-1903. The two departments were reunited in 1904.

Paleontologist's annual reports 1899-1903.

See fourth note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with geologist's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882-date.

Reports 3–19 bound also with museum reports 40–46, 48–57 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	9	$.25	15 (En 9)	$.15
2	.30	10	.35	16 (" 10)	.25
5	.25	11	.25	17 (" 14)	.30
6	.15	12	.25	18 (" 17)	.20
7	.20	13	.10	19 (" 21)	.15
8	.25	14 (En 5)	.20	20 *In press*	

Reports 2, 8-12 may also be obtained bound separately in cloth at 25c in addition to the price given above.

Botanist's annual reports 1867-date.

Bound also with museum reports 21–date of which they form a part; the first botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports 25–28, 30, 42–50 and 52 (Botany 3) are out of print. Report 51 may be had for 40c; 53 for 20c; 54 for 50c. Since the 55th these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have been published in volumes 1 and 3 of the 48th museum report and in volume 1 of the 49th, 51st, 52d, 54th and 55th reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum memoir 4.

Museum bulletins 1887-date. O. *To advance subscribers, $2 a year or 50c a year for those of any one division:* (1) *geology, economic geology, mineralogy,* (2) *general zoology, archeology and miscellaneous,* (3) *paleontology,* (4) *botany,* (5) *entomology.*

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
G 1	48, v.1	Pa 1	54, v.1	En 7–9	53, v.1	Ar 3	52, v.1
2	51, v.1	2, 3	" v.3	10	54, v.2	4	54, v.1
3	52, v.1	4	" v.4	11	" v.3	5	" v.3
4	54, v.4	5, 6	55, v.1	12, 13	" v.4	6	55, v.1
5	56, v.1	7–9	56, v.2	14	55, v.1	7	56, v.4
Eg 5, 6	48, v.1	Z 3	53, v.1	15–18	56, v.3	Ms 1, 2	" v.4
7	50, v.1	4	54, v.1	Bo 3	52, v.1		
8	53, v.1	5–7	" v.3	4	53, v.1	Memoir	
9	54, v.2	8	55, v.1	5	55, v.1	2	49, v.3
10	" v.3	9	56, v.3	6	56, v.4	3, 4	53, v.2
11	56, v.1	En 3	48, v 1	Ar 1	50, v.1		
M 2	" v.1	4–6	52, v.1	2	51, v.1		

The figures in parenthesis in the following list indicate the bulletin's number as a New York State Museum bulletin.

Geology. G1 (14) Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co. N. Y., with notes on the iron mines. 38p. 7pl. 2 maps. Sep. 1895. *10c.*

G2 (19) Merrill, F: J. H. Guide to the Study of the Geological Collections of the New York State Museum. 162p. 119pl. map. Nov. 1898. [*50c*]

G3 (21) Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sep. 1898. *5c.*

G4 (48) Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 9pl. map. Dec. 1901. *25c.*

G5 (56) Merrill, F: J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Oct. 1902. *10c.*

G6 (77) Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. *30c.*

G7 (83) Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. *25c.*

G8 (84) —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. 11pl. 18 maps. July 1905. *45c.*

G9 (95) Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sep. 1905. *30c.*

Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. *In press.*

Economic geology. Eg1 (3) Smock, J: C. Building Stone in the State of New York. 152p. Mar. 1888. *Out of print.*

Eg2 (7) —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 6+70p. map. June 1889. *Out of print.*

Eg3 (10) —— Building Stone in New York. 210p. map, tab. Sep. 1890. *40c.*

Eg4 (11) Merrill, F: J. H. Salt and Gypsum Industries of New York. 92p. 12pl. 2 maps, 11 tab. Ap. 1893. [*50c*]

Eg5 (12) Ries, Heinrich. Clay Industries of New York. 174p. 2pl. map. Mar. 1895. *30c.*

Eg6 (15) Merrill, F: J. H. Mineral Resources of New York. 224p. 2 maps. Sep. 1895. [*50c*]

Eg7 (17) —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps 34x45, 68x92 cm. Oct. 1897. *15c.*

Maps separate *10c each, two for 15c.*

Eg8 (30) Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. *15c.*

Eg9 (35) Ries, Heinrich. Clays of New York; their Properties and Uses. 456p. 140pl. map. June 1900. *$1, cloth.*

Eg10 (44) —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. *85c, cloth.*

Eg11 (61) Dickinson, H. T. Quarries of Bluestone and other Sandstones in New York. 108p. 18pl. 2 maps. Mar. 1903. *35c.*

Eg12 (85) Rafter, G: W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. *$1.50, cloth.*

Eg13 (93) Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *15c.*

Mineralogy. M1 (4) Nason, F. L. Some New York Minerals and their Localities. 20p. 1pl. Aug. 1888. [*10c*]

M2 (58) Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sep. 1902. *40c.*

M3 (70) —— New York Mineral Localities. 110p. Sep. 1903. *20c.*

Paleontology. Pa1 (34) Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C: S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 10pl. map. May 1900. *15c.*

Pa2 (39) Clarke, J: M.; Simpson, G: B. & Loomis, F: B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. *15c.*

Contents: Clarke, J: M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
——Paropsonema cryptophya; a peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
——Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
——The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G: B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F: B. Siluric Fungi from Western New York.

Pa3 (42) Ruedemann, Rudolf. Hudson River Beds near Albany and their Taxonomic Equivalents. 114p. 2pl. map. Ap. 1901. *25c.*

Pa4 (45) Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Ap. 1901. *65c; cloth, 90c.*

Pa5 (49) Ruedemann, Rudolf; Clarke, J: M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *40c.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J: M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co. N. Y
Clarke, J: M. New Agelacrinites.
——Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

Pa6 (52) Clarke, J: M. Report of the State Paleontologist 1901. 280p. il. 9pl. map, 1 tab. July 1902. *40c.*

Pa7 (63) —— Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. *25c.*

Pa8 (65) —— Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. *$1.20, cloth.*

Pa9 (69) —— Report of the State Paleontologist 1902. 464p. 52pl. 8 maps. Nov. 1903. *$1, cloth.*

Pa10 (80) —— Report of the State Paleontologist 1903. 396p. 20pl. map. Feb. 1905. *85c, cloth.*

Pa11 (81) —— & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. *25c.*

Pa12 (82) —— Geologic Map of the Tully Quadrangle. 40p. map. Ap. 1905. *20c.*

Luther, D. D. Geology of the Buffalo Quadrangle. *In press.*

Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. *In press.*

Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. *In preparation.*

Zoology. Z1 (1) Marshall, W: B. Preliminary List of New York Unionidae. 20p. Mar. 1892. *5c.*

Z2 (9) —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 24p. 1pl. Aug. 1890. *10c.*

Z3 (29) Miller, G. S. jr. Preliminary List of New York Mammals. 124p. Oct. 1899. *15c.*

Z4 (33) Farr, M. S. Check List of New York Birds. 224p. Ap. 1900. *25c.*

Z5 (38) Miller, G. S. jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. *15c.*

Z6 (40) Simpson, G: B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. *25c.*

Z7 (43) Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Ap. 1901. *10c.*

Z8 (51) Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Ap. 1902. *15c.*

Eckel, E. C. Serpents of Northeastern United States
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

Z9 (60) Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. *$1, cloth.*

Z10 (71) Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sep. 1903. *10c.*

Z11 (88) Letson, Elizabeth J. Check List of the Mollusca of New York. 114p. May 1905. *20c.*

Z12 (91) Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. *20c.*

Eaton, E. H. Birds of New York. *In preparation.*

Entomology. En1 (5) Lintner, J. A. White Grub of the May Beetle. 32p. il. Nov. 1888. *10c.*

En2 (6) —— Cut-worms. 36p. il. Nov. 1888. *10c.*

En3 (13) —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Ap. 1895. *15c.*

En4 (20) Felt, E. P. Elm-leaf Beetle in New York State. 46p. il. 5pl. June 1898. *5c.*

See En15.

En5 (23) —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. *20c.*

En6 (24) —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874-98; Index to Entomologist's Reports 1-13. 316p. 1pl. Oct. 1899. *35c.*

Supplement to 14th report of the state entomologist.

En7 (26) —— Collection, Preservation and Distribution of New York Insects. 36p. il. Ap. 1899. *5c.*

En8 (27) —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. *5c.*

En9 (31) —— 15th Report of the State Entomologist 1899. 128p. June 1900. *15c.*

En10 (36) —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. *25c.*

En11 (37) —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sep. 1900. *10c.*

En12 (46) —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. *25c.*

En13 (47) Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sep. 1901. *45c.*

En14 (53) Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *30c.*

En15 (57) —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *15c.*

This is a revision of En4 containing the more essential facts observed since that was prepared.

En16 (59) —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. *15c.*

See En19.

En17 (64) —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. *20c.*

En18 (68) Needham, J. G. *& others.* Aquatic Insects in New York. 322p. 52pl. Aug. 1903. *80c, cloth.*

En19 (72) Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. *20c.*

This is a revision of En16 containing the more essential facts observed since that was prepared.

En20 (74) —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. *25c.*

En21 (76) Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. *15c.*

En22 (79) —— Mosquitos or Culicidae of New York. 164p. il. 57pl. Oct. 1904. *40c.*

En23 (86) Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. 1905. *80c, cloth.*

Felt, E. P. 20th Report of the State Entomologist 1904. *In press.*

Botany. Bo1 (2) Peck, C: H. Contributions to the Botany of the State of New York. 66p. 2pl. May 1887. *Out of print.*

Bo2 (8) —— Boleti of the United States. 96p. Sep. 1889. [50c]

Bo3 (25) —— Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print.*

Bo4 (28) —— Plants of North Elba. 206p. map. June 1899. *20c.*

Bo5 (54) —— Report of the State Botanist 1901. 58p. 7pl. Nov. 1902. *40c.*

Bo6 (67) —— Report of the State Botanist 1902. 196p. 5pl. May 1903. *50c.*

Bo7 (75) —— Report of the State Botanist 1903. 70p. 4pl. 1904. *40c.*

Bo8 (94) —— Report of the State Botanist 1904. 60p. 10pl. July 1905. *40c.*

Archeology. Ar1 (16) Beauchamp, W: M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. *25c.*

Ar2 (18) —— Polished Stone Articles used by the New York Aborigines. 104p. 35pl. Nov. 1897. *25c.*

Ar3 (22) —— Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. *25c.*

Ar4 (32) —— Aboriginal Occupation of New York. 190p. 16pl. 2 maps. Mar. 1900. *30c.*

Ar5 (41) —— Wampum and Shell Articles used by New York Indians. 166p. 28pl. Mar. 1901. *30c.*

Ar6 (50) —— Horn and Bone Implements of the New York Indians. 112p. 43pl. Mar. 1902. *30c.*

Ar7 (55) —— Metallic Implements of the New York Indians. 94p. 38pl. June 1902. *25c.*

Ar8 (73) —— Metallic Ornaments of the New York Indians. 122p. 37pl. Dec. 1903. *30c.*

Ar9 (78) —— History of the New York Iroquois. 340p. 17pl. map. Feb. 1905. *75c, cloth.*

Ar10 (87) —— Perch Lake Mounds. 84p. 12pl. Ap. 1905. *20c.*

Ar11 (89) —— Aboriginal Use of Wood in New York. 190p. 35pl. June 1905. *35c.*

Miscellaneous. Ms1 (62) Merrill, F: J. H. Directory of Natural History Museums in United States and Canada. 236p. Ap. 1903. *30c.*

Ms2 (66) Ellis, Mary. Index to Publications of the New York State Natural History Survey and New York State Museum 1837-1902. 418p. June 1903. *75c, cloth.*

Museum memoirs 1889-date. Q.

1 Beecher, C: E. & Clarke, J: M. Development of some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. *Out of print.*

2 Hall, James & Clarke, J: M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. *$1, cloth.*

3 Clarke, J: M. The Oriskany Fauna of Becraft Mountain, Columbia Co. N. Y. 128p. 9pl. Oct. 1900. *80c.*

4 Peck, C: H. N. Y. Edible Fungi, 1895-99. 106p. 25pl. Nov. 1900. *75c.*

This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the state botanist.

5 Clarke, J: M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. *$1.50, cloth.*

6 —— Naples Fauna in Western New York. 268p. 26pl. map. *$2, cloth.*

7 Ruedemann, Rudolf. Graptolites of New York. Pt 1 Graptolites of the Lower Beds. 350p. 17pl. Feb. 1905. *$1.50, cloth.*

Felt, E. P. Insects Affecting Park and Woodland Trees. *In press.*

Clarke, J: M. Early Devonic of Eastern New York. *In preparation.*

Natural history of New York. 30v. il. pl. maps. Q. Albany 1842-94.

DIVISION 1 ZOOLOGY. De Kay, James E. Zoology of New York; or, The New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. 5v. il. pl. maps. sq. Q. Albany 1842-44. *Out of print.*

Historical introduction to the series by Gov. W: H. Seward. 178p.

v. 1 pt1 Mammalia. 13+146p. 33pl. 1842.

300 copies with hand colored plates.

v. 2 pt2 Birds. 12+380p. 141pl. 1844.
Colored plates.

v. 3 pt3 Reptiles and Amphibia. 7+98p. pt4 Fishes. 15+415p. 1842.
pt3-4 bound together.

v. 4 Plates to accompany v. 3. Reptiles and Amphibia 23pl. Fishes 79pl. 1842.
300 copies with hand-colored plates.

v. 5 pt5 Mollusca. 4+271p. 40pl. pt6 Crustacea. 70p. 13pl. 1843-44.
Hand-colored plates: pt5-6 bound together.

DIVISION 2 BOTANY. Torrey, John. Flora of the State of New York; comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State, with remarks on their economical and medical properties. 2v. il. pl. sq. Q. Albany 1843. *Out of print.*

v. 1 Flora of the State of New York. 12+484p. 72pl. 1843.
300 copies with hand-colored plates.

v. 2 Flora of the State of New York. 572p. 89pl. 1843.
300 copies with hand-colored plates.

DIVISION 3 MINERALOGY. Beck, Lewis C. Mineralogy of New York; comprising detailed descriptions of the minerals hitherto found in the State of New York, and notices of their uses in the arts and agriculture. il. pl. sq. Q. Albany 1842. *Out of print.*

v. 1 pt1 Economical Mineralogy. pt2 Descriptive Mineralogy. 24+536p. 1842.
8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W: W.; Emmons, Ebenezer; Vanuxem, Lardner & Hall, James. Geology of New York. 4v. il. pl. sq. Q. Albany 1842-43. *Out of print.*

v. 1 pt1 Mather, W: W. First Geological District. 37+653p. 46pl. 1843.

v. 2 pt2 Emmons, Ebenezer. Second Geological District. 10+437p. 17pl. 1842.

v. 3 pt3 Vanuxem, Lardner. Third Geological District. 306p. 1842.

v. 4 pt4 Hall, James. Fourth Geological District. 22+683p. 19pl. map. 1843.

DIVISION 5 AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. Q. Albany 1846-54. *Out of print.*

v. 1 Soils of the State, their Composition and Distribution. 11+371p. 21pl. 1846.

v. 2 Analysis of Soils, Plants, Cereals, etc. 8+343+46p. 42pl. 1849.
With hand-colored plates.

v. 3 Fruits, etc. 8+340p. 1851.

v. 4 Plates to accompany v. 3. 95pl. 1851.
Hand-colored.

v. 5 Insects Injurious to Agriculture. 8+272p. 50pl. 1854.
With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Palaeontology of New York. 8v. il. pl. sq. Q. Albany 1847-94. *Bound in cloth.*

v. 1 Organic Remains of the Lower Division of the New York System. 23+338p. 99pl. 1847. *Out of print.*

v. 2 Organic Remains of Lower Middle Division of the New York System. 8+362p. 104pl. 1852. *Out of print.*

v. 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt1, text. 12+532p. 1859. [*$3.50*]

—— pt2, 143pl. 1861. [*$2.50*]

v. 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11+1+428p. 99pl. 1867. *$2.50.*

v. 5 pt1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups. 18+268p. 45pl. 1884. *$2.50.*

—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62+293p. 51pl. 1885. *$2.50.*

—— pt2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v.1, text. 15+492p. v.2, 120pl. *$2.50 for 2v.*

—— & Simpson, George B. v.6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24+298p. 67pl. 1887. *$2.50.*

—— & Clarke, John M. v.7 Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64+236p. 46pl. 1888. Cont. supplement to v.5, pt2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. *$2.50.*

—— & Clarke, John M. v.8, pt1 Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16+367p. 44pl. 1892. *$2.50.*

—— & Clarke, John M. v.8, pt2 Paleozoic Brachiopoda. 16+394p. 84pl. 1894. *$2.50.*

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. O. 1853.

Handbooks 1893-date. 7½x12½ cm.

In quantities, 1 cent for each 16 pages or less. Single copies postpaid as below.

H5 New York State Museum. 52p. il. *4c.*

Outlines history and work of the museum with list of staff 1902.

H13 Paleontology. 12p. *2c.*

Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

H15 Guide to Excursions in the Fossiliferous Rocks of New York. 124p. *8c.*

Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially for the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

H16 Entomology. 16p. *2c.*

H17 Economic Geology. 44p. *4c.*

H18 Insecticides and Fungicides. 20p. *3c.*

H19 Classification of New York Series of Geologic Formations. 32p. *3c.*

Maps. Merrill, F: J. H. Economic and Geologic Map of the State of New York; issued as part of Museum bulletin 15 and the 48th Museum Report, v. 1. 59x67 cm. 1894. Scale 14 miles to 1 inch. *15c.*

—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form $3; mounted on rollers $5. Lower Hudson sheet 60c.*

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. *15c.*

Geologic maps on the United States Geological Survey topographic base; scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.

*Albany county. Mus. rep't 49, v. 2. 1898. *50c.*

Area around Lake Placid. Mus. bul. 21. 1898.

Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. Mus. rep't 51, v. 1. 1899.

Rockland county. State geol. rep't 18. 1899.

Amsterdam quadrangle. Mus. bul. 34. 1900.

*Parts of Albany and Rensselaer counties. Mus. bul. 42. 1901. *10c.*

*Niagara River. Mus. bul. 45. 1901. *25c.*

Part of Clinton county. State geol. rep't 19. 1901.

Oyster Bay and Hempstead quadrangles on Long Island. Mus. bul. 48. 1901.

Portions of Clinton and Essex counties. Mus. bul. 52. 1902.

Part of town of Northumberland, Saratoga co. State geol. rep't 21. 1903.

Union Springs, Cayuga county and vicinity. Mus. bul. 69. 1903.

*Olean quadrangle. Mus. bul. 69. 1903. *10c.*

Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) Mus. bul. 69. 1903. *20c.*

*Canandaigua-Naples quadrangles. Mus. bul. 63. 1904. *20c.*

*Little Falls quadrangle. Mus. bul. 77. 1905. *15c.*

*Watkins-Elmira quadrangle. Mus. bul. 81. 1905. *20c.*

*Tully quadrangle. Mus. bul. 82. 1905. *10c.*

*Salamanca quadrangle. Mus. bul. 80. 1905. *10c.*

v. 1 pt1 Economical Mineralogy. pt2 Descriptive Mineralogy. 24 + 536p. 1842.

8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W. W.; Emmons, Ebenezer; Vanuxem, Lardner & Hall, James. Geology of New York. 4v. il. pl. sq. Q. Albany 1842–43. *Out of print.*

v. 1 pt1 Mather, W. W. First Geological District. 37 + 653p. 46pl. 1843.

v. 2 pt2 Emmons, Ebenezer. Second Geological District. 10 + 437p. 17pl. 1842.

v. 3 pt3 Vanuxem, Lardner. Third Geological District. 306p. 1842.

v. 4 pt4 Hall, James. Fourth Geological District. 22 + 683p. 19pl. map. 1843.

DIVISION 5 AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. Q. Albany 1846–54. *Out of print.*

v. 1 Soils of the State, their Composition and Distribution. 11 + 371p. 21pl. 1846.

v. 2 Analysis of Soils, Plants, Cereals, etc. 8 + 343 + 46p. 42pl. 1849.

With hand-colored plates.

v. 3 Fruits, etc. 8 + 340p. 1851.

v. 4 Plates to accompany v. 3. 95pl. 1851.

Hand-colored.

v. 5 Insects Injurious to Agriculture. 8 + 272p. 50pl. 1854.

With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Palaeontology of New York. 8v. il. pl. sq. Q. Albany 1847–94. *Bound in cloth.*

v. 1 Organic Remains of the Lower Division of the New York System. 23 + 338p. 99pl. 1847. *Out of print.*

v. 2 Organic Remains of Lower Middle Division of the New York System. 8 + 362p. 104pl. 1852. *Out of print.*

v. 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt1, text. 12 + 532p. 1859. [*$3.50*]

—— pt2. 143pl. 1861. [*$2.50*]

v. 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11 + 1 + 428p. 99pl. 1867. *$2.50.*

v. 5 pt1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups. 18 + 268p. 45pl. 1884. *$2.50.*

—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62 + 293p. 51pl. 1885. *$2.50.*

—— pt2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v. 1, text. 15 + 492p. v. 2, 120pl. *$2.50 for 2 v.*

—— & Simpson, George B. v. 6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24 + 298p. 67pl. 1887. *$2.50.*

—— & Clarke, John M. v. 7 Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. *$2.50.*

—— & Clarke, John M. v. 8 pt1 Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16 + 367p. 44pl. 1892. *$2.50.*

—— & Clarke, John M. v. 8 pt2 Paleozoic Brachiopoda. 16 + 394p. 84pl. 1894. *$2.50.*

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. O. 1853.

Handbooks 1893–date. 7½x12½ cm.

In quantities, 1 cent for each 16 pages or less. Single copies postpaid as below.

New York State Museum. 52p. il. *4c.*

Outlines history and work of the museum with list of staff 1902.

Paleontology. 12p. *2c.*

Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

Guide to Excursions in the Fossiliferous Rocks of New York. 124p. *8c.*

Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially for the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

Entomology. 16p. *2c.*
Economic Geology. 44p. *4c.*
Insecticides and Fungicides. 20p. *3c.*
Classification of New York Series of Geologic Formations. 32p. *3c.*
Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum bulletin 15 and 48th Museum Report, v. 1. 59x67 cm. 1894. Scale 14 miles to 1 inch. *15c.*
—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. Mus. bul. 17. 1897. *10c.*
—— Map of the State of New York Showing the Distribution of the Rocks Most Useful for Road Metal. Mus. bul. 17. 1897. *5c.*
—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form $3; mounted on rollers $5. Lower Hudson sheet 60c.*

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York Showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. *15c.*
—— Map of the State of New York Showing the Location of its Economic Deposits. 1904. Scale 12 miles to 1 inch. *15c.*
Geologic maps on the United States Geological Survey topographic base; scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.
*Albany county. Mus. rep't 49, v. 2. 1898. *50c.*
Area around Lake Placid. Mus. bul. 21. 1898.
Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. Mus. rep't 51, v. 1. 1899.
Rockland county. State geol. rep't 18. 1899.
Amsterdam quadrangle. Mus. bul. 34. 1900.
*Parts of Albany and Rensselaer counties. Mus. bul. 42. 1901. *10c.*
*Niagara river. Mus. bul. 45. 1901. *25c.*
Part of Clinton county. State geol. rep't 19. 1901.
Oyster Bay and Hempstead quadrangles on Long Island. Mus. bul. 48. 1901.
Portions of Clinton and Essex counties. Mus. bul. 52. 1902.
Part of town of Northumberland, Saratoga co. State geol. rep't 21. 1903.
Union Springs, Cayuga county and vicinity. Mus. bul. 69. 1903.
*Olean quadrangle. Mus. bul. 69. 1903. *10c.*
*Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) Mus. bul. 69. 1903. *20c.*
*Canandaigua-Naples quadrangles. Mus. bul. 63. 1904. *20c.*
*Little Falls quadrangle. Mus. bul. 77. 1905. *15c.*
*Watkins-Elmira quadrangle. Mus. bul. 81. 1905. *20c.*
*Tully quadrangle. Mus. bul. 82. 1905. *10c.*
*Salamanca quadrangle. Mus. bul. 80. 1905. *10c.*
*Buffalo quadrangle. Mus. bul. 99. 1906. *10c.*

Map of the State of New York showing the location of its economic deposits

New York State Museum

The New York State Museum as at present organized is the outgrowth of the Natural History Survey of the State commenced in 1836. This was established at the expressed wish of the people to have some definite and positive knowledge of the mineral resources and of the vegetable and animal forms of the State. This wish was stated in memorials presented to the Legislature in 1834 by the Albany Institute and in 1835 by the American Institute of New York city and as a result of these and other influences the Legislature of 1835 passed a resolution requesting the secretary of state to report to that body a plan for "a complete geological survey of the State, which shall furnish a scientific and perfect account of its rocks, soils and materials and of their localities; a list of its mineralogical, botanical and zoological productions and provide for procuring and preserving specimens of the same; etc."

Pursuant to this request, Hon. John A. Dix, then secretary of state, presented to the Legislature of 1836 a report proposing a plan for a complete geologic, botanic and zoologic survey of the State. This report was adopted by the Legislature then in session and the governor was authorized to employ competent persons to carry out the plan which was at once put into effect.

The scientific staff of the Natural History Survey of 1836 consisted of John Torrey, botanist; James E. DeKay, zoologist; Lewis C. Beck, mineralogist; W. W. Mather, Ebenezer Emmons, Lardner Vanuxem and Timothy A. Conrad, geologists. In 1837 Professor Conrad was made paleontologist and James Hall, who had been an assistant to Professor Emmons, was appointed geologist to succeed Professor Vanuxem, who took Professor Conrad's place.

The heads of the several departments reported annually to the governor the results of their investigations, and these constituted the annual octavo reports which were published from 1837 to 1841. The final reports were published in quarto form, beginning at the close of the field work in 1841, and 3000 sets have been distributed, comprising four volumes of geology, one of mineralogy, two of botany, five of zoology, five of agriculture, and eight of paleontology.

3 2044 074 412 990

3 2044 074 412 990